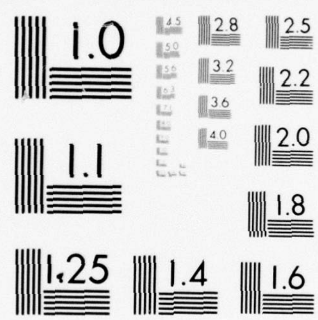
AD-A078 818 KENTON ENGINEERING CORP SKOKIE ILL F/G 9/2
STUDY OF EFFECTIVENESS OF REHABILITATION METHODS FOR ANALOG MAG--ETC(U)
DEC 71 E A ROBERTS, R E ZENNER, T R THOMAS N00014-70-C-0327
UNCLASSIFIED 6200-2 NL

1 OF 1
ADA
078818

END
DATE
FILMED
1-80
DDC



MICROCOPY RESOLUTION TEST CHART

UNCLASSIFIED
Security Classification

479 673

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) KENTON ENGINEERING CORPORATION	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED
	2b. GROUP N/A
3. REPORT TITLE Study of Effectiveness of Rehabilitation Methods for Analog Magnetic Tape	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Quarterly Report, no. 2, 1 October 1971 — 31 December 1971	
5. AUTHOR(S) (Last name, first name, initial) Roberts, Edward A.; Zenner, Raymond E.; Thomas, T. Roy	Edward A. Roberts, Raymond E. Zenner, T. Roy Thomas
6. REPORT DATE 31 December 1971	7a. TOTAL NO. OF PAGES 75 / 7b. NO. OF REFS None
8a. CONTRACT OR GRANT NO. N00014-70-C-0327	9a. ORIGINATOR'S REPORT NUMBER(S) 6200-2
b. PROJECT NO. NRL Req'n 00173-0-006318	
c. 77	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) None
d.	
10. AVAILABILITY/LIMITATION NOTICES ~~Naval Research Laboratory, Code 5473, Washington, D. C.~~	DISTRIBUTION STATEMENT A Approved for public release; Distribution Unlimited
11. SUPPLEMENTARY NOTES None	12. SPONSORING MILITARY ACTIVITY Naval Research Laboratory, Code 5473 Washington, D. C. 20390

13. ABSTRACT

Two tape condition monitors have been constructed and are in the final test phase at the end of this report period. Instructions for Operation and Servicing are ready for delivery with these equipments.

Preliminary measurements on three lots of tapes for test cleaning have been completed. One lot of cleaned tapes has been received at Kenton for "after cleaning" measurements. Dropout data at various tape speeds and wavelengths are reported.

Progress in magnetic tape transport simulation studies is reported.

NRL 479,673 400572

DISCLAIMER NOTICE

REPORT 6200-2

STUDY OF EFFECTIVENESS OF REHABILITATION METHODS FOR ANALOG MAGNETIC TAPE

Second Quarterly Report

1 October 1971 -- 31 December 1971

Submitted to:
Naval Research Laboratory
Washington, D. C. 20390

Attention: Code 5473

Research Sponsored by the
Office of Naval Research

ONR Contract No. N00014-70-C-0327

NRL Requisition 00173-0-006318

KENTON ENGINEERING CORPORATION - SKOKIE, ILLINOIS

A. INTRODUCTION

This report covers work performed under Contract N00014-70-C-0327 during the 1 October - 31 December quarter. Research areas covered relate to the specific tasks outlined in Exhibit A and which are referenced in Modification P00001 of the contract.

The work includes continuing of the studies of rehabilitation effectiveness for instrumentation tapes; an additional quantity of these tapes with known use histories have been furnished to us by the Navy for the purpose of verifying our earlier reported results. These continued studies in this area are to provide further confirmation of the dry cleaning approach for rehabilitating heavy duty use tapes, the goal being to demonstrate that the process of reconditioning is repeatable and independent of the time, place, operator or the specific cleaning machine used.

Studies conducted during the first year of this program utilized special instrumentation for counting dropouts. During the same time period the Navy conducted field tests with a Tape Condition Monitor furnished by Kenton Engineering Corporation. In both situations, in our laboratory and in the field, it was demonstrated that such monitoring instrumentation can be employed to effectively sort out tapes whose performance has deteriorated to unacceptable levels. As a follow-on to this work, two prototype Tape Condition Monitors will be furnished during this contract extension period. These instruments are discussed under Task I of Section D in this report.

Additional studies of dropouts occurring in magnetic tapes are also being conducted under this contract modification. A Government furnished recorder/reproducer with a spinning head subsystem for scanning stopped or slowly moving magnetic tape will be used to locate, identify and study the nature of the specific types of dropouts which occur in these heavy duty use tapes. Other experiments will be conducted during this contract extension period which are to provide a better understanding of the dropout phenomenon encountered in tapes used in analog data recording. The Government furnished recorders and other equipments available at our plant will be used in these experiments and in related studies. In particular, studies will be conducted which investigate the effects of tape dropouts on performance of the speed control servo system of the AN/FSH-7 recorder/reproducer. The speed control reference signal, recorded on the tape, can be conditioned in various ways; factors which optimize signal conditioning will be determined.

B. PREVIOUS WORK

Initial work under this contract called for a study of effectiveness of the various available tape cleaning methods -- to determine feasibility of employing such techniques for rehabilitation of instrumentation tapes which are used in major Naval systems and subject to heavy duty use. Evaluation of 120 reels of magnetic tape, 1 inch in width by 14 inches diameter by 5,000 feet in length, each with a known history of use, was undertaken in this earlier study. These tapes were initially measured for dropouts, then forwarded to a tape rehabilitation center for cleaning (or some cases the cleaning was accomplished

at the Naval Research Laboratory or at our plant). Dropout measurements were repeated after the cleaning process -- to determine what beneficial effects, if any, resulted from each of the cleaning processes.

In addition to obtaining favorable results for some of these rehabilitation methods -- principally those falling into the category of "dry cleaning", it was demonstrated that monitoring instrumentation can be effectively employed to remove, on the basis of their dropout characteristics, those tapes that have deteriorated in performance beyond a point of useful field application. It was further indicated that portions of tapes that have been damaged can be identified by the monitor and that the useful life of a tape can be extended by replacement of such damaged sections.

Present contract investigations are based upon a logical extension of the favorable results obtained from the initial tape rehabilitation studies. This work extends into four technical areas, identified as Tasks I, II, III and IV, on which progress is described in Section D of this report.

C. STEERING COMMITTEE MEETING

On December 14th and 15th, 1971, a project meeting was held at Kenton Engineering Corporation to discuss status of work being performed under this contract and on other related work. Under Task I, where two (2) Tape Condition Monitors are being furnished, the following was reported Except for a few missing electronic components (meter and diodes) and the chart paper, all of which will be received shortly from our vendors, these units are complete and ready for checkout. Instructions for operation and servicing the instruments were also reviewed by the NRL representatives and these instructions were approved and released for printing. The two prototype instruments were observed in the shop in the final stage of assembly.

Reported as work completed under Task II of this contract, were the "Before Cleaning" measurements on the additional quantity of 35 heavy duty use tapes. These tapes have been divided into three lots for cleaning purposes. NRL reported that the first lot of 12 tapes, cleaned at a government facility where a GKI 680 dry cleaner is available, was being returned to Kenton for the "after cleaning" measurements.

Kenton reported that the second lot of 12 tapes had recently been sent to the GKI Tape Service Co. in Reston, Va. for rehabilitation and that the third lot of 11 tapes were being held at our plant for the Task III wave-length studies. Cleaning of the third tape lot is also scheduled to be performed by GKI Tape Service Co. later in the program.

Dropouts measured as a function of tape speed and wavelength was reported for the eleven tapes assigned to thisstudy. These measurements are being conducted on the CEC VR 2800, with all combinations of the following: tape speed 15, 30 and 60 ips; wavelengths show no unexpected results, except that some increase in the number of dropouts were recorded when reducing tape speed from 60 ips to 15 ips with the wavelength held constant. Tape tension was checked at all three speeds in the run approaching first contact with the capstan. All readings were in the range 10 - 14 oz for beginning, middle and end of tape supply at all three speeds. This tape drive is one of the "closed loop" type; that is, the tape contacts the same capstan before and after contacting the heads. Tape tension changes within the "closed loop" as a function of tape speed may be the reason for the observed dropout data.

Measurements being conducted on this project phase should be completed by the end of December. At that time the Task III investigations will be redirected to the spinning head studies of individual dropouts. It was requested by the NRL representatives that a shift in emphasis is desired relative to work to be performed in the area of tape dropouts. Considerable time has elapsed since these studies were proposed and field experience has provided practical answers to some of the problems, therefore, we were instructed to curtail work on sharply contoured heads and de-emphasize dropout measurements at high tape speeds and long wavelengths. An investigation and literature survey of recent work that may have been reported in this area of dropout identification will be undertaken by NRL -- to determine whether any useful information for this project has been reported by others.

Material generated in all phases of these NRL programs will be reviewed by members of the project steering committee with a view toward possible publications in the refereed technical journals. Synopses or abstracts will be developed as a first step in preparation of material for publication.

Task IV modeling studies which involve the AN/FSH-7 transport were reported by Dr. Thomas. This work has proceeded to the computer-aided analysis stage and has provided gain vs. frequency response data for this simulated capstan-servo model. Computer programs available for both tape and tachometer modes of operation were discussed. Data in Nyquist and Bode form were displayed which indicate the effect of changing system parameters on performance stability. Correlation with experimental work has been achieved in some areas; effort is being directed to further improve correlation so that the computer analysis will be increasingly useful in the AN/FSH-7 support contract work.

As part of the above studies, NRL representatives requested Dr. Thomas to commence evaluation of a number of proposed high density digital recording methods which are now under consideration. This work is to be summarized and reported as part of the Task IV b studies.

D. REPORT OF WORK IN PROGRESS

TASK I -- PROTOTYPE TCMs

Construction and checkout of the two (2) prototype Tape Condition Monitors (TCMs), Kenton Model 6152, Serial B1 and Serial B2, has been completed. Except for new chart paper which we will be receiving within a few days and one meter -- which proved to be defective and is being replaced by the vendor, the instruments are ready for delivery. In the meantime these TCMs are being operated around-the-clock to assure their reliable performance in the field.

The Model 6152 is similar to the Model 6152 (XN-1) Service Test Model, but with the following changes in functions and characteristics.

1. Rack mount instead of bench mount.

2. Choice of -12 db or -6 db dropouts instead of only -12 db.

3. Maximum count of 4000 dropouts instead of 2000.

4. 125 KHz crystal oscillator included in Model 6152.

5. Provision for electrical reset to zero count from external equipment instead of built-in 15-minute clock reset.

6. One volt full scale voltmeter instead of two volt.

7. TTL compatible pulses to external equipment instead of one volt pulses.

The Model 6152 detects dropouts greater than a selected value of -12 db or -6 db in a 125 KHz carrier and accumulates the count of such dropouts until reset to zero, either by an externally supplied +30 volt, ten second pulse, or action of a manual pushbutton within the instrument. The data is presented on a 24-hour circular chart, driven by a 60 Hz synchronous motor. There is provision for setting the chart to the actual time of day. Factory setting of dropouts is at the -12 db level. The block diagram of the Model 6152 TCM is shown in Figure I-1.

The carrier input impedance of the instrument is greater than 5000 ohms and the instrument will operate on carrier levels from 50 MV RMS to 1 V RMS without manual gain control. The electronics include an AGC circuit and a carrier level voltmeter having a 1 V RMS scale. A plug-in 125 KHz filter is included, which permits the presence of composite signal data on the instrument input without impairing the basic function of the Tape Condition Monitor.

The rectified and filtered carrier operates a trigger circuit if dropouts greater than the selected value occur. Pulses from this trigger are brought to a BNC connector for use in external equipment and are also used to operate an internal scale of 40 electronic counter. Completion of a cycle of this counter causes a solenoid (advance solenoid) to advance a 100 tooth ratchet wheel one tooth. A cam on the ratchet wheel shaft determines position of the chart pen. The pen is advanced in steps equal to 1/100 of full scale. Thus, full scale on the chart corresponds to 4000 dropouts (40 x 100).

To accomplish reset to zero count, a second solenoid (holding solenoid) is actuated along with the advance solenoid. When both are actuated, the holding pawl and the advance pawl are retracted from the ratchet wheel teeth, allowing a spring to rotate the ratchet, cam, and pen arm to the zero count position. A dashpot is provided to prevent violent deceleration of the zero count stop position.

The crystal oscillator circuit is designed to accept crystals of 50 to 500 KHz series resonant frequency without need for retuning. A 125 KHz crystal is supplied in Model 6152. Output from a BNC connector is 1 V RMS (no load) from a source of 50 ohms.

The basic 24 hour chart drive and pen are parts of the Bristol Model IUD 530-24 recorder which has been extensively modified to produce the Kenton Model 6152 Tape Condition Monitor.

Four (4) copies of the Instructions for Operation and Servicing will be furnished with the instruments. These instructions also cover installation and provide a complete parts list, in addition to the electrical and mechanical servicing and adjustment procedures.

TASK II -- VERIFICATION OF TAPE REHABILITATION METHOD

Dropout studies prior to cleaning were completed on the lot of 35 heavy duty use instrumentation tapes made available for this program task. These tapes, identified in quarterly report 6200-1, are similar in use history to the 120 tapes which were studied earlier and described in the 30 June 1971 summary report.

In this present study, these 35 tapes are divided into two lots of 12 and a third lot of 11 tapes, with individual tapes selected so that each lot is represented by similar use histories. Dropout counts for these precleaned tapes and dropout rates (counts per minute), were measured on tracks 1 and 8, by determining the number of dropouts occurring at the -12 db level in a 125 KHz recorded carrier at 60 ips, on the CEC VR 2800 recorder-reproducer. These measurements are tabulated in Table II-1. Also, Figures II-1 to II-35 provide plots of dropout data for these precleaned tapes as a function of time.

These tapes are all scheduled to be cleaned by the GKI 680 dry process, which was the most effective of the several rehabilitation methods investigated earlier in this program. The principle of operation of this dry cleaning process is to remove dirt, particles of oxide and backing material which has become dislodged from the tape -- by means of a cleaning blade which scrapes the oxide surface of the tape. The loosened debris is then removed by fabric wipers which contact both sides of the tape. While the GKI 680 cleaner is not unique in this cleaning method, earlier results showed it to be the most effective of the several rehabilitation techniques that were evaluated. To confirm these earlier findings, which showed that the -12 db dropouts were reduced to 22 percent of their precleaned totals on track 1, and to 31% on track 8, this identical cleaning process will be repeated on these three tape lots. Cleaning operations will be performed at different rehabilitation centers and at various times in this program -- so that operators and the specific cleaning equipment are not always the same.

Lot 1, cleaned at a government rehabilitation center, has now been returned to our plant for "after cleaning" measurements. Lot 2 has recently been sent to the GKI Tape Service Company at Reston, Va. The third lot of 11 tapes are being retained at our plant for work described under Task III which follows. These tapes will be sent out for cleaning later in the program.

TASK III -- ADDITIONAL DROPOUT STUDIES

All of the previous dropout studies have been conducted on the CEC VR 2800 recorder-reproducer at a tape speed of 60 ips and with a recorded carrier of 125 KHz. The criteria for determining when a dropout has occurred is the measurement of a reduction in reproduced signal amplitude of the carrier of at least 12 decibels. The eleven (11) tapes identified as lot 3 in the Task II work have now been assigned to the additional task of exploring the relationship between various tape speeds, wavelengths and number of dropouts registered on these tapes. Because major emphasis has been placed on other phases of this study, the scope of these measurements is necessarily restricted. All measurements, therefore, are limited to center track 8, and at the -12 db level. All combinations of 1/4, 1/2, 1 and 2 mil wavelengths and 15, 30 and 60 ips tape speeds are covered in these measurements. The tapes were bulk erased and the transport was cleaned after every pass with TEC-SOLV 928. Tape tension was measured at each speed, at the beginning, middle and end of each tape reel -- to insure that this parameter remained constant, (maximum variations in tension were from 10 to 13 ounces). While time of the tape runs vary inversely with tape speed, measurements of total number of dropouts under all conditions represent the total tape length, 4500 feet. The standard laboratory dropout instrumentation, employed in the Task II work was used for these additional dropout studies, except that the 125 KHz input filter was eliminated and the carrier ripple filter following the detector was changed from 10 to 2 KHz -- to eliminate low frequency (7.5 and 15 KHz) carrier ripple from getting through to the counter.

Total number of dropouts measured under the above conditions are listed in Table III-1. Also, plots of dropouts vs. time at the four wavelengths -- all at 60 ips tape speed are provided in Figures III-1 through III-2. Analysis of these data and additional graphic presentations will be included in future reports.

TASK IV — MAGNETIC TAPE TRANSPORT SIMULATION STUDIES

1. General Remarks:

During this period, work continued on a theoretical model of a servo-controlled magnetic tape transport. Computer programming, testing and operating was begun on a series of tasks to develop the transfer function of the system.

Results of this work are preliminary, in that further refinements to the model will be made, so that the physical machine is emulated in a useful fashion. A series of figures illustrating current results are included. These graphs are most useful for illustrating the effect of certain parameters on the operation of the model. They do not give an exact replica of the performance of the physical machine; although interesting parallels can be seen with closed loop measurements made in the FSH-7 machine, through a comparison of Figure IV-8(2) and Figure IV-8A.

2. Computer Programs

A number of programs have been written in Fortran. They are designed for limited use on a time-share terminal. These programs are discussed in Appendix A and an example of how the programs operate is given.

One of the tasks, in representing a system by a series of programs, is to determine how well the theoretical model can simulate the physical machine. When the physical machine is available, measurements on the machine are ideal to test the program. Based on these criteria the model and machine do agree in a broad sense. Differences do occur in detail as will be pointed out. A description of the results obtained from calculations using these programs is discussed in the following.

3. Results of Calculations

At this stage, the model may be used to give valuable insight into the understanding of the servo operation. In fact, parallel operation of the calculations and physical measurements has proved to be mutually beneficial and stimulating.

Referring to Figure IV-4, portions of two polar plots are shown. The logarithm of the response amplitude is plotted against the phase in degrees. According to the Nyquist theory, the curve plotted must not pass through the gain point 1, (0 db) and -180 degrees, nor must it pass this point from the wrong direction. The plot in Figure 4 is for the tachometer controlled mode at the reproduce station. The parameter varied for the two curves is JR, the total inertia of the motor armature, capstan and pinch rolls. The nominal system value is .01 oz-in-sec. For this particular system configuration, the stability requirement is that the trajectory of the plot must pass through the gain of one circle, here 0 db, with a phase shift of less than -180 degrees. For the set of parameters used, curve (1), the gain margin is approximately 5 db (B-C); the phase margin is 50 degrees (D-C). Any reduction in gain will decrease damping and eventually the system will become unstable.

Increasing the system inertia parameter, JR, reduces the system gain. Hence larger motors with reduced torque to inertia ratios will have degrading effects, unless the system gain is increased a compensating amount. Curve number (2) shows the trajectory for a JR of .03. This curve indicates an unstable system; but the system will become stable if the gain is increased by at least 4 db; an increase of 10 db would make the system similar to the reduced inertia case, curve (1).

Another interesting parameter is TD, the damping torque of the inertia roller. Figure 5 shows the polar plot of the system under tape control for several values of damping torque. It can be seen that values of TD less than about .5 oz-in per radian per second are unstable. In addition the curves begin to move in a less stable direction for values of TD of 2 oz-in per radian per second. The nominal value of TD for the FSH-7 can be calculated from detailed manufacturing information. In the remaining data, a value of 1. is assumed.

Figure IV-6 and Figure IV-7 show polar plots for the record and reproduce stations in the tachometer control mode. The two curves are different due to the different stabilization networks. The gain margin at the record station is 20 db, but only 5 db at the reproduce station. The phase margins are 42 degrees and 65 degrees.

The closed loop gain as a function of frequency for the two stations are shown in Figure IV-8. Curve (1) represents the record station and Curve (2), the reproduce station. The closed loop frequency response is the amplitude of the output with respect to an input reference demand. Since the system can be easily reduced to a unity feedback circuit, the input, output ratio can be measured physically at any convenient point in the circuit loop. Such measurements have been made in the FSH-7 at Kenton Engineering and provide accurate data on the closed loop response, so long as the amplitude remains in a linear region and the system is stable. A measured curve for tachometer control at the reproduce station is shown in Figure IV-8A and can be compared with the calculated curve Figure IV-8(2).

At the low frequency end the curves are flat at 0 db. This indicates that the system will accurately reproduce the input demands at these frequencies (over an amplitude range which is linear). At about 64 cycles both responses have amplitudes higher than 0 db. This means that the output is over-reacting to the input and produces outputs of higher amplitude than the input. On the rising slopes of these curves the outputs are in phase with the demand. Curve (2), the reproduce station, shows a peak of 7 db at 95 cycles. This means that the output is about twice as large as desired at this frequency; if the input signal were an attempt to cure a position error, presumably 180 degrees out of phase with the input, then an error would still remain, of about equal amplitude, but shifted 180 degrees with respect to the original error. From a point of view of flutter correction, no change would result. Beyond this first peak, phase shift begins to occur, and depending on the phase and amplitude, flutter may actually be increased. The curves eventually assume negative db values of gain. This means the system does not respond to the input except in a feeble way. The response is degrading when the phase shift exceeds 60 degrees.

The curves (1) and (2) show quite different amplitude characteristics. The reproduce station curve (2) peaks sharply at 95 cycles. Referring back to Figure 7, the reason can be seen in the small gain margin. The record station curve has a low peak; referring to Figure IV-6, there is adequate gain margin. However, the broad peak may prove to be undesireable.

Also plotted in Figure IV-8 are the open loop extensions of the amplitude characteristics. These show a sharp peak at 5000 Hertz. This is caused by the torsional resonance of the tachometer disc with respect to the main inertia of the motor. With no damping this peak is about +36 db at the reproduce capstan. With damping, parameter B2, of 1.0 inch-oz per radian per second the system would appear to be approaching a stable condition. Closed loop tests on the FSH-7 machine indicate some selected motors to be unstable at this frequency.

The block diagram of the configuration used to compute the tachometer response is shown in Figure IV-9. Calculations using this model, do not show the sharp dip in amplitude immediately below the peak, see Figures IV-8 and IV-8A, further checking between the model and the physical machine is required.

E. SUMMARY AND FUTURE WORK

Progress under Contract N00014-71-C-0327 during the period from 1 October to 31 December 1971 is reported. Task I work is essentially completed. The two Tape Condition Monitors (TCMs) Kenton Models 6152, now undergoing life testing in our laboratory, will be delivered to the Navy in January, together with instructions for operation and servicing. These prototype instruments are similar to the Service Test Model which the Navy has been field testing for some time, except that these prototypes have some added features which are described in Section D, Task I. With these field instruments, together with data accumulated during dropout studies conducted in the laboratory, it has been demonstrated that reliable and repeatable measurements can be made on these heavy duty use tapes while they are being used in their normal function -- to show where on the tape, in what quantity and at what rate the dropouts occur. Deployment of these TCMs will provide for more cost effective use of these tapes.

The tape rehabilitation studies have progressed to the stage where all of the 35 tapes furnished for verification of the earlier reported favorable results have passed through their "precleaning" measurements. Tapes are divided into three lots, each of which are being cleaned separately — at different times in the program and at different rehabilitation stations. "After cleaning" measurements will be performed on two of these lots in the very near future. The third lot of tapes are being held at our plant. They will be cleaned later in the program. If, as anticipated, a substantial reduction in dropouts result from the "dry cleaning" process described in Section D, Task II, then additional experiments will be conducted on these tapes to determine whether the rehabilitation process remains effective during their continued use.

Other tape studies reported under Task III consider the effects of wavelength and tape speed changes on the measured dropouts. These data will be analyzed and correlated with field results that are now becoming available. Studies of individual dropouts will also be conducted by means of a spinning head tape reproducer available as GFE. This work will commence in January.

Relative to the Task IV studies, it is apparent from a comparison of the theoretical calculations and actual measurements that the FSH-7 system as originally supplied is a reasonable design. It does, however, lack flexibility in its ability to accept design variations in replacement elements. For example, on capstan motors, motors of lower torque-to-inertia ratios might be used if adjustments could be made to the system gain. In addition, there is little built-in compensation for motor-shaft torsional resonances at high frequencies. One would expect that inherently stable motors can and should be supplied.

It has not been determined at this time how optimal the original compensation networks are with regard to system overshoot and settling time. This will be investigated.

Future work will also involve further testing and refinements on the model developed. Calculations will be made to indicate the response of the system to disturbing torques. Speed errors occur in the physical system because of a variety of imperfections and discontinuities in the system components. It may be possible to develop criteria for the frequency responses of the system to minimize such disturbances.

TABLE II-1

TOTAL DROPOUTS MEASURED AT THE -12 DB LEVEL IN 4500 FT OF TAPE (15 MIN. AT 60 ips)

Lot No.	Tape No.	Prev. Use	Dropouts Track 1	Dropouts Track 8
1	X2V-S14	4	417	254
1	X1F-R04	18	158	162
1	X2V-R15	18	492	1294
1	X1S-A12	156	17160	1620
1	X2V-A27	292	7560	5560
1	X1S-A27	318	28300	3400
1	X1S-R11	462	37370	5408
1	X1S-A63	468	37476	5900
1	X2H-R01	486	10900	2386
1	X1S-A09	505	3480	908
1	Y3S-A47	537	1522	840
1	Z1C-S05	682	2382	277
2	Y3S-R13	6	225	345
2	X2J-R09	18	2808	5198
2	X1S-R13	152	21700	10300
2	X2H-R03	167	1655	59
2	X1S-S12	317	6835	4988
2	X2J-R07	318	4680	1095
2	X2C-A02	463	11700	458
2	X1F-A16	481	7510	1879
2	X2H-S01	486	4330	1089
2	Z1C-A62	505	2744	397
2	X3S-A47	624	6477	1455
2	Y1C-A87	739	3620	553
3	X1S-R14	18	344	1121
3	X2V-R14	18	688	435
3	X1S-A87	156	2790	1197
3	X3S-A75	281	5630	1999
3	Z2C-A27	317	3350	618
3	Y1C-R06	347	6175	347
3	X2V-R11	466	6475	3107
3	X2J-S06	482	12560	2200
3	Z2C-R04	496	24200	422
3	Y3S-A55	510	2240	2300
3	X1F-A43	633	4725	3053

TABLE III-1. DROPOUTS MEASURED AS A FUNCTION OF WAVELENGTH AND TAPE SPEED - TRACK 8 - 4500 FT OF TAPE

λ = .25 mils			λ = .5 mils			λ = 1.0 mil			λ = 2.0 mils			Tape No.
15 ips	30 ips	60 ips	15 ips	30 ips	60 ips	15 ips	30 ips	60 ips	15 ips	30 ips	60 ips	
3935	3230	2237	2819	851	796	1276	363	227	803	139	145	X1S-R14
2678	1432	1050	1525	498	318	670	225	169	388	97	84	X2V-R14
7101	4831	3157	4365	1618	1199	2361	865	630	1729	336	348	X1S-A87
4060	3032	3054	3159	1875	1890	2217	1157	1015	1751	540	712	X3S-A75
4644	2276	2137	2613	922	614	1550	476	314	1010	203	215	Z2C-A27
3583	2774	1611	2201	658	318	1249	426	162	926	189	109	Y1C-R06
8940	6761	5416	5956	2942	2442	3652	1439	1103	2540	516	754	X2V-R11
5830	4351	3450	4366	2365	2080	2935	1905	1280	2480	651	830	X2J-S06
2187	1396	865	1403	579	410	904	369	248	651	189	188	Z2C-R04
7020	4717	3545	5609	3100	2500	4081	1975	1507	3167	805	962	Y3S-A55
14920	11636	8397	10474	4367	3711	6325	1925	1571	4083	718	832	X1F-A43
60	120	240	30	60	120	15	30	60	7.5	15	30	Freq. KHz

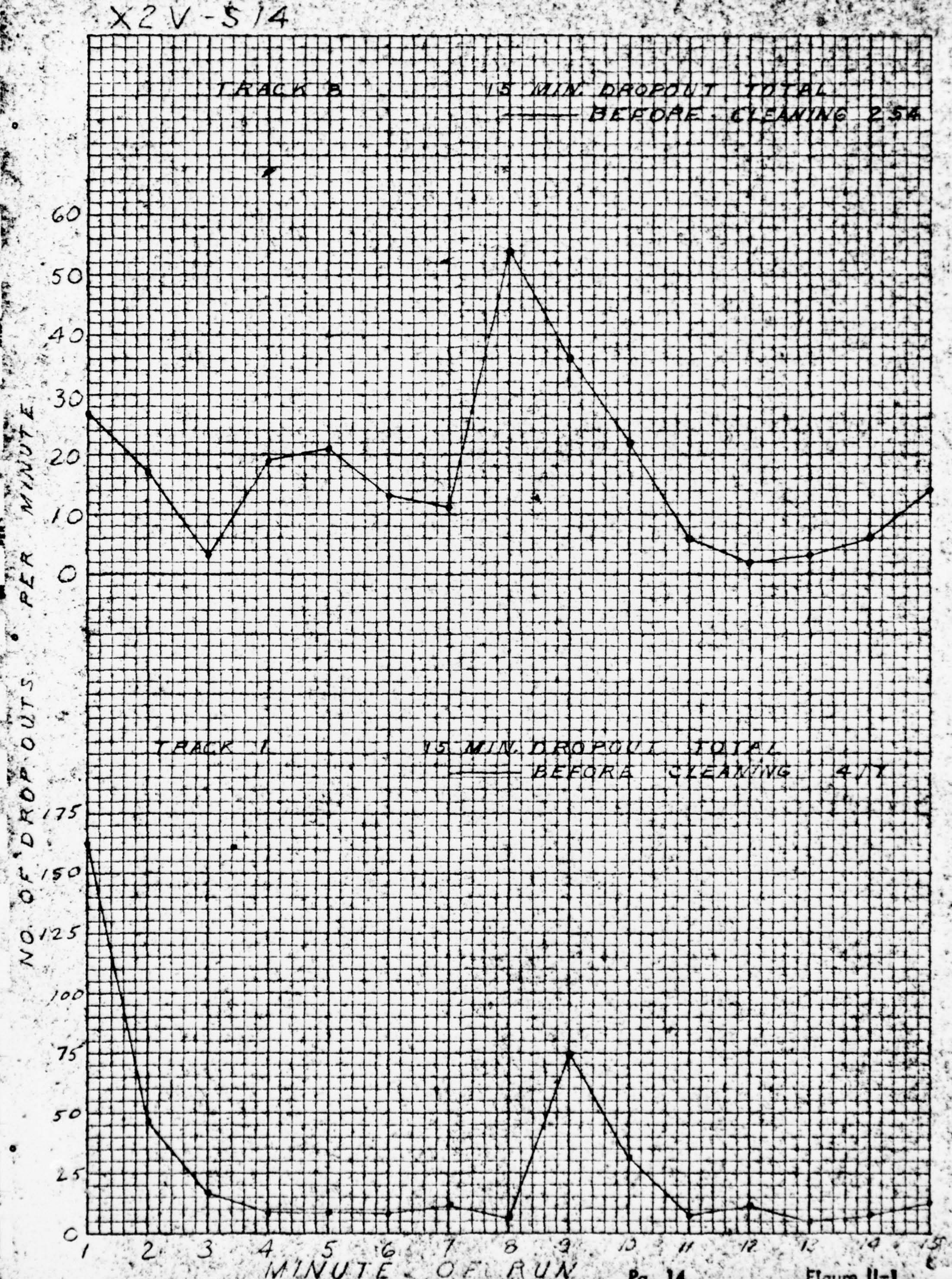

X2V-514
TRACK 8
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 254
TRACK 1
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 417
NO. OF DROP OUTS PER MINUTE
MINUTE OF RUN
60
50
40
30
20
10
0
175
150
125
100
75
50
25
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Figure II-1

XIF-R04

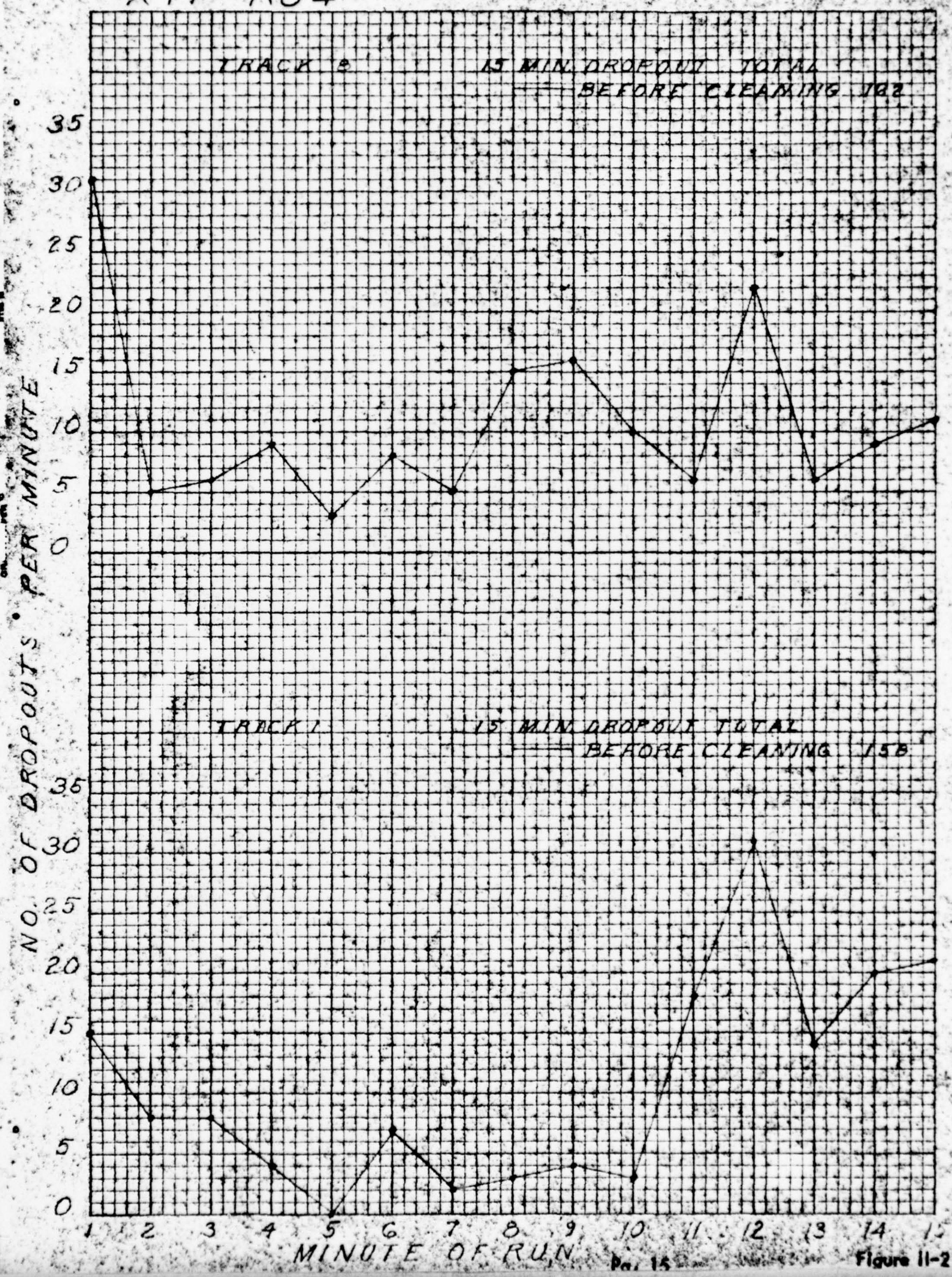


Figure II-2

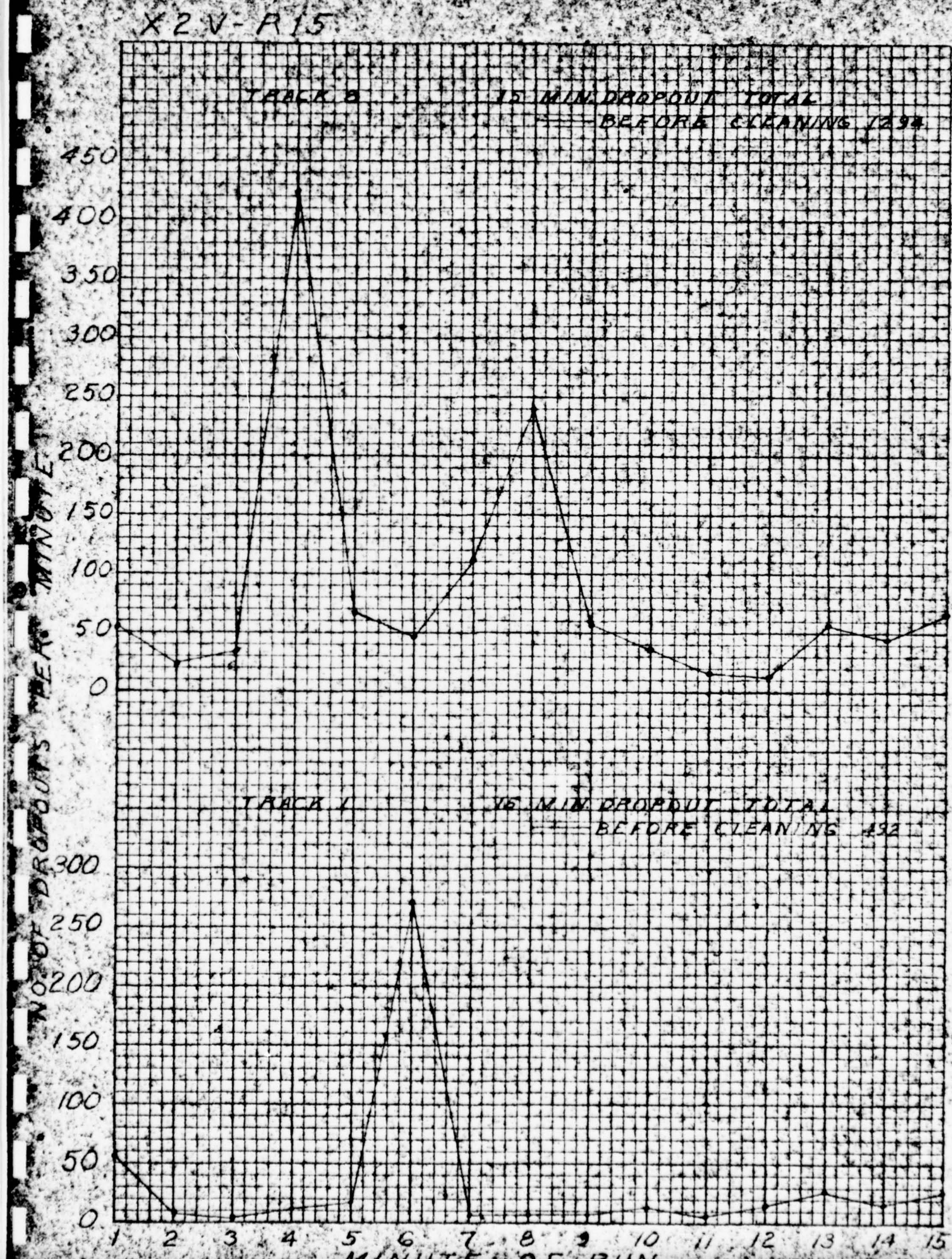
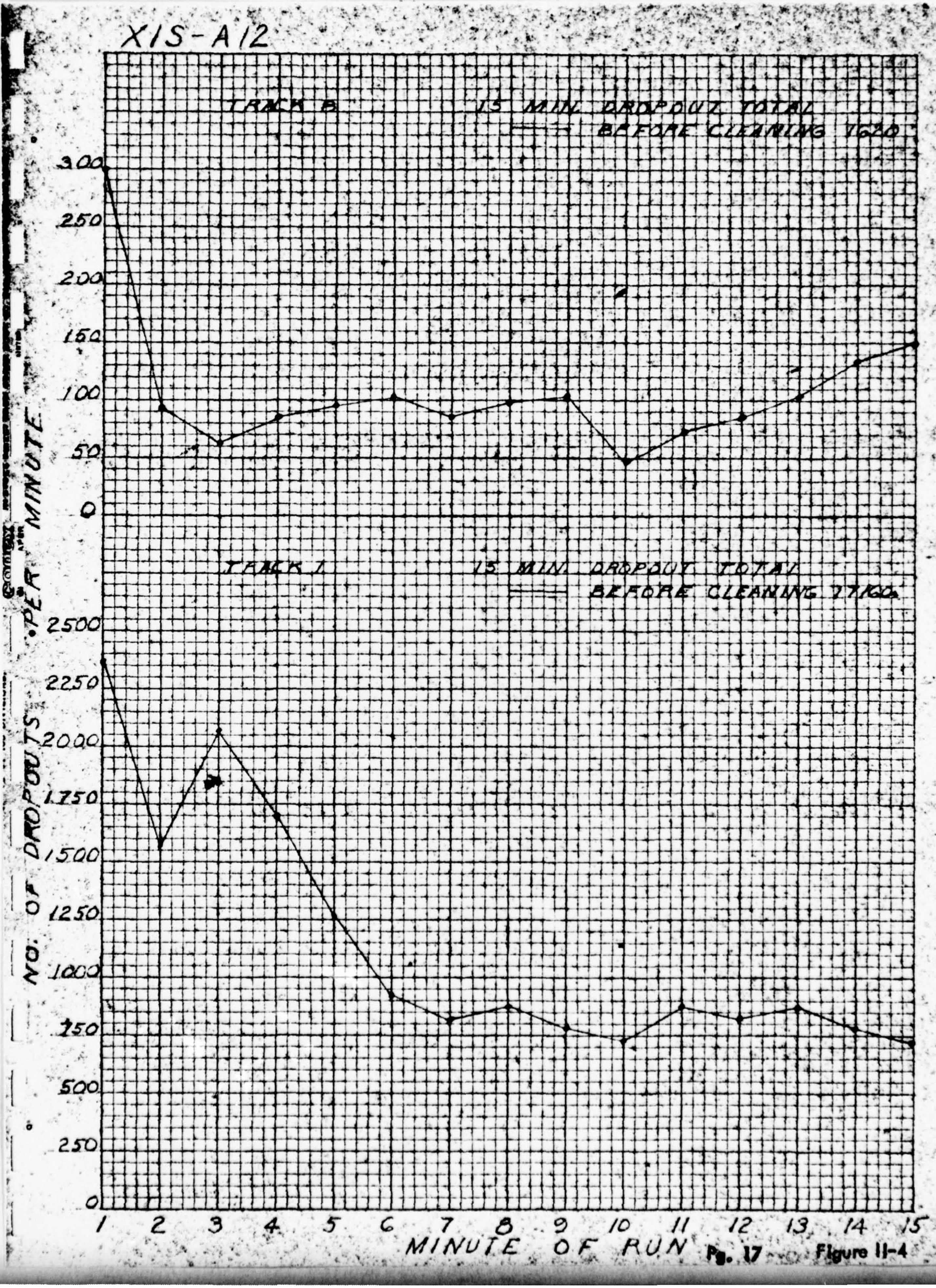
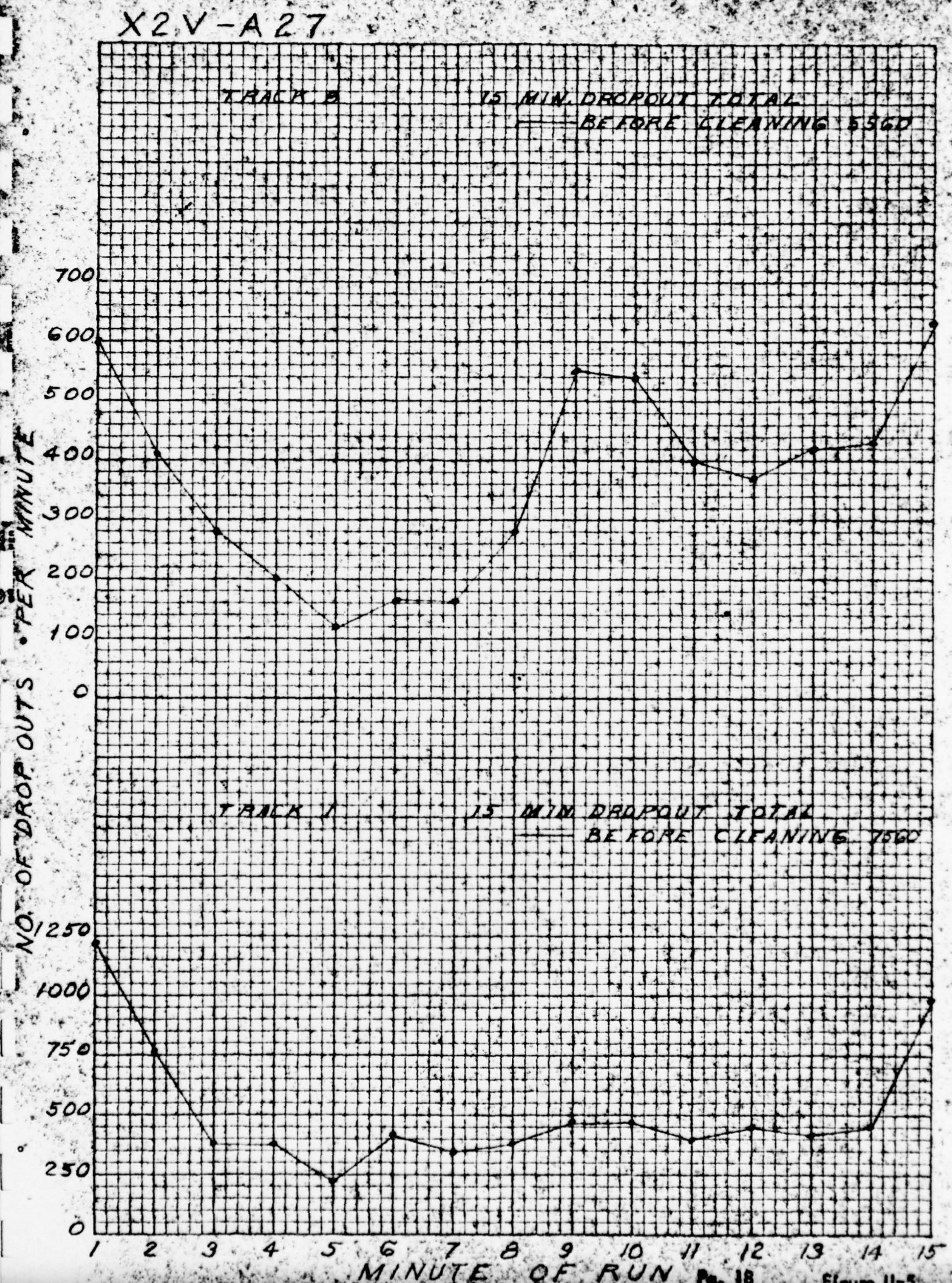

X2V-R15
TRACK 8
15 MIN DROPOUT TOTAL
BEFORE CLEANING 1294
TRACK 1
15 MIN DROPOUT TOTAL
BEFORE CLEANING 432
NO. OF DROPOUTS PER MINUTE
450
400
350
300
250
200
150
100
50
0
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
MINUTE OF RUN

Figure 11-2



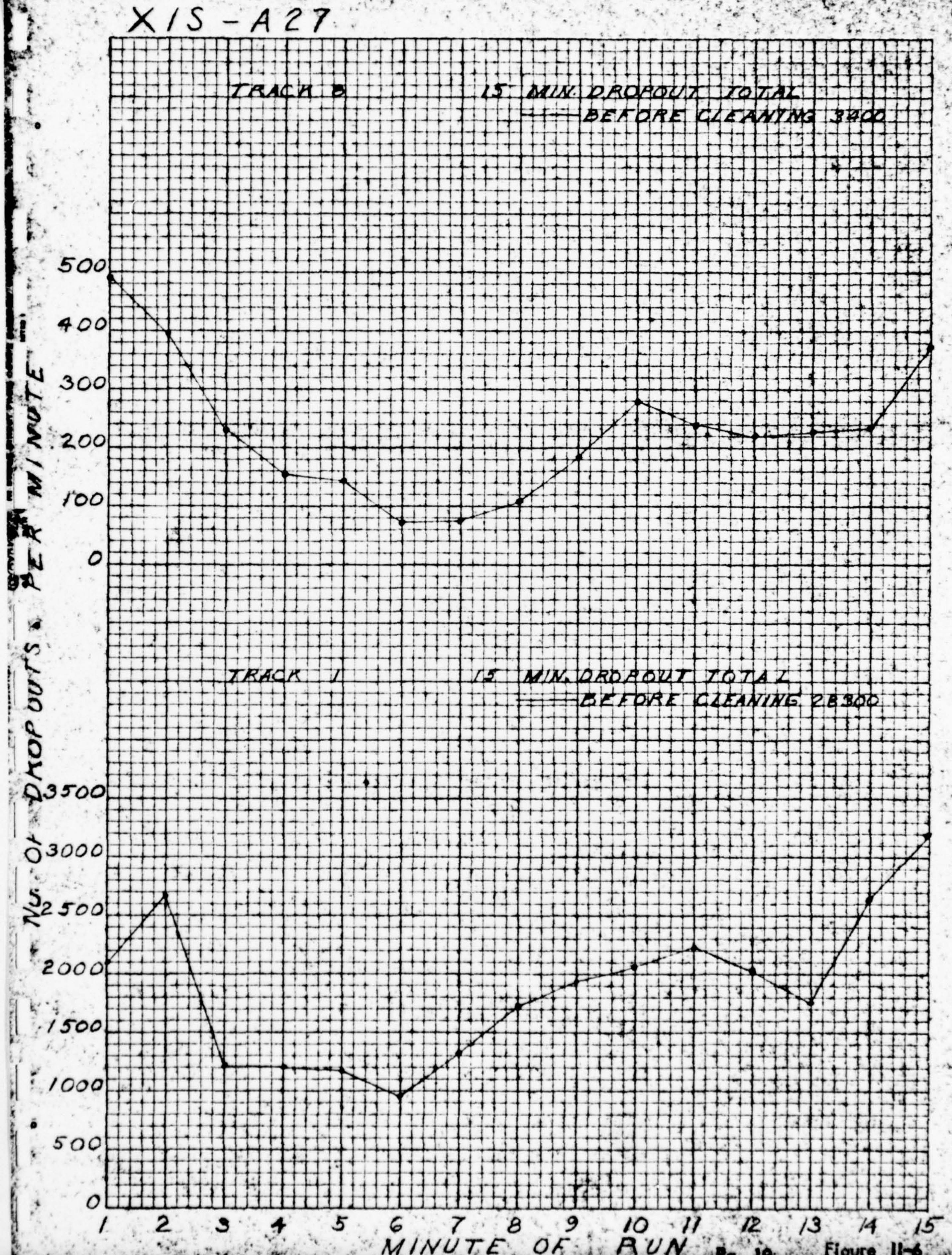
XIS-A12
TRACK 8
15 MIN DROPOUT TOTAL BEFORE CLEANING 1620
TRACK 1
15 MIN DROPOUT TOTAL BEFORE CLEANING 17160
NO. OF DROPOUTS PER MINUTE
300
250
200
150
100
50
0
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
MINUTE OF RUN

Figure II-4



X2V-A27
TRACK B
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 5560
700
600
500
400
300
200
100
0
NO. OF DROP OUTS PER MINUTE
TRACK 1
15 MIN DROPOUT TOTAL
BEFORE CLEANING 7560
1250
1000
750
500
250
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
MINUTE OF RUN

Figure II-5



X1S - A27
TRACK 8
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 3400
TRACK 1
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 28300
NO. OF DROPOUTS PER MINUTE
0
100
200
300
400
500
0
500
1000
1500
2000
2500
3000
3500
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
MINUTE OF RUN

 Figure II-6

XIS-R11

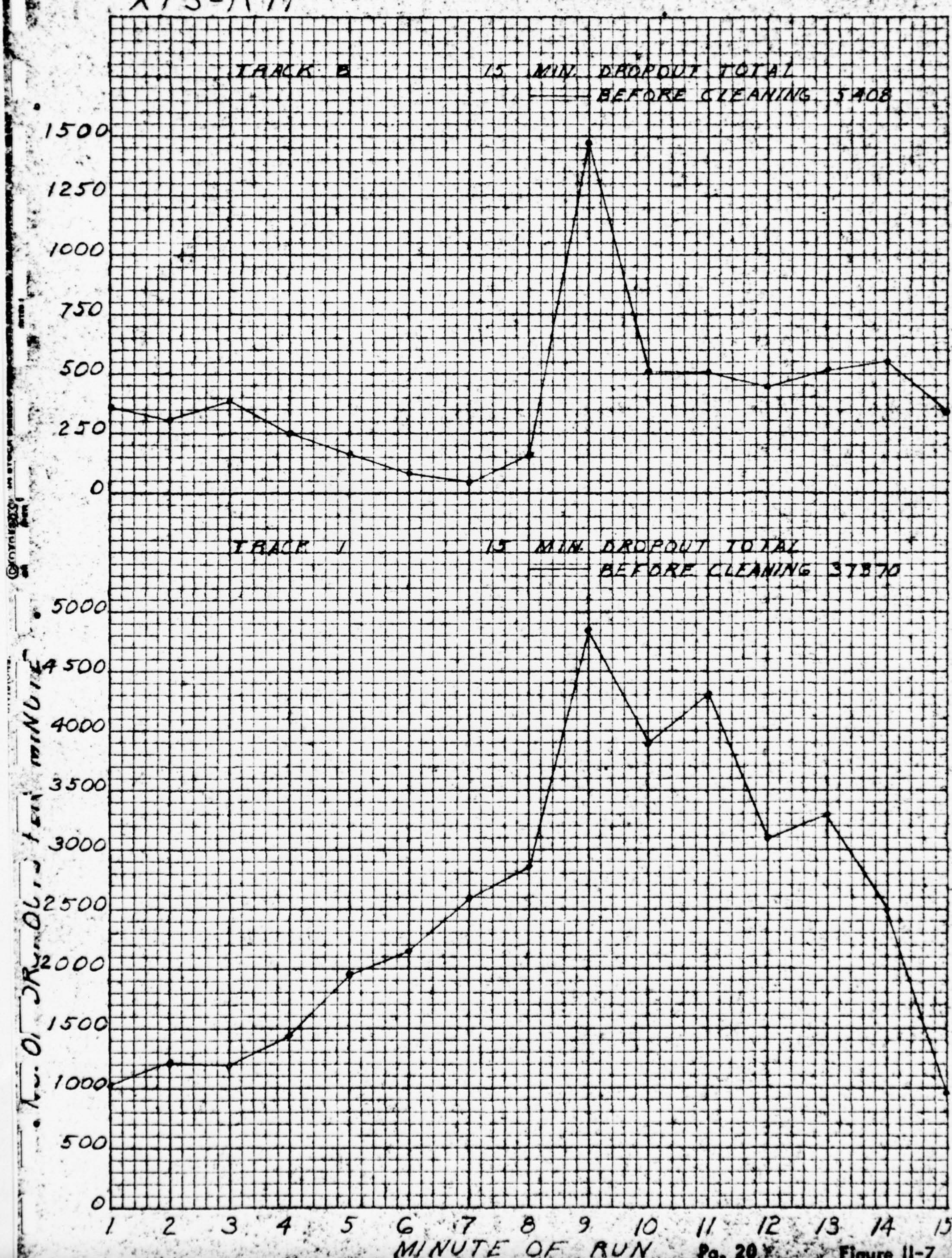


 Figure II-7

XIS-A63

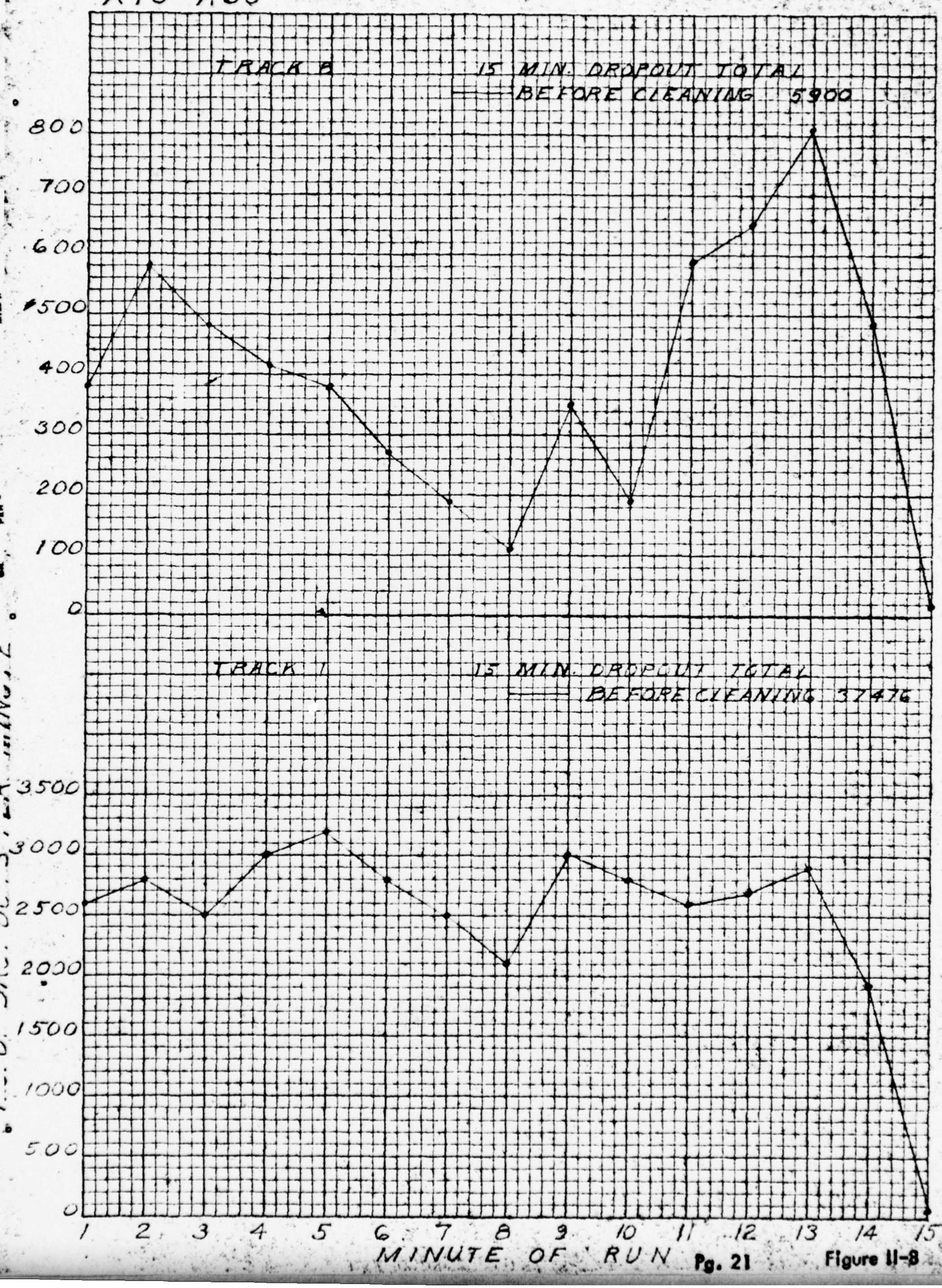
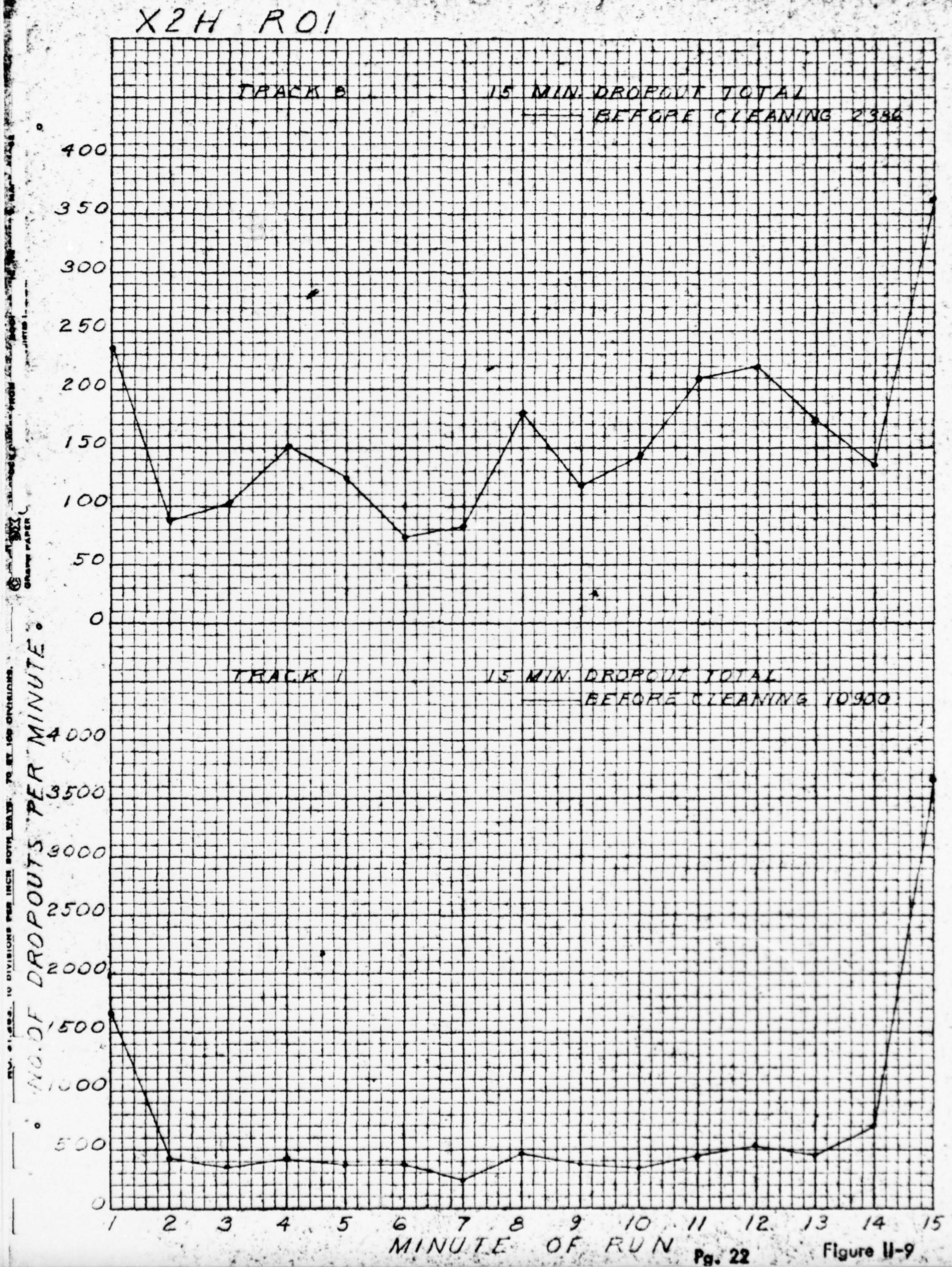


Figure II-8



X2H R01
TRACK 8
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 2336
400
350
300
250
200
150
100
50
0
TRACK 1
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 10900
4000
3500
3000
2500
2000
1500
1000
500
0
NO. OF DROPOUTS PER MINUTE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
MINUTE OF RUN

Figure II-9

XIS A09

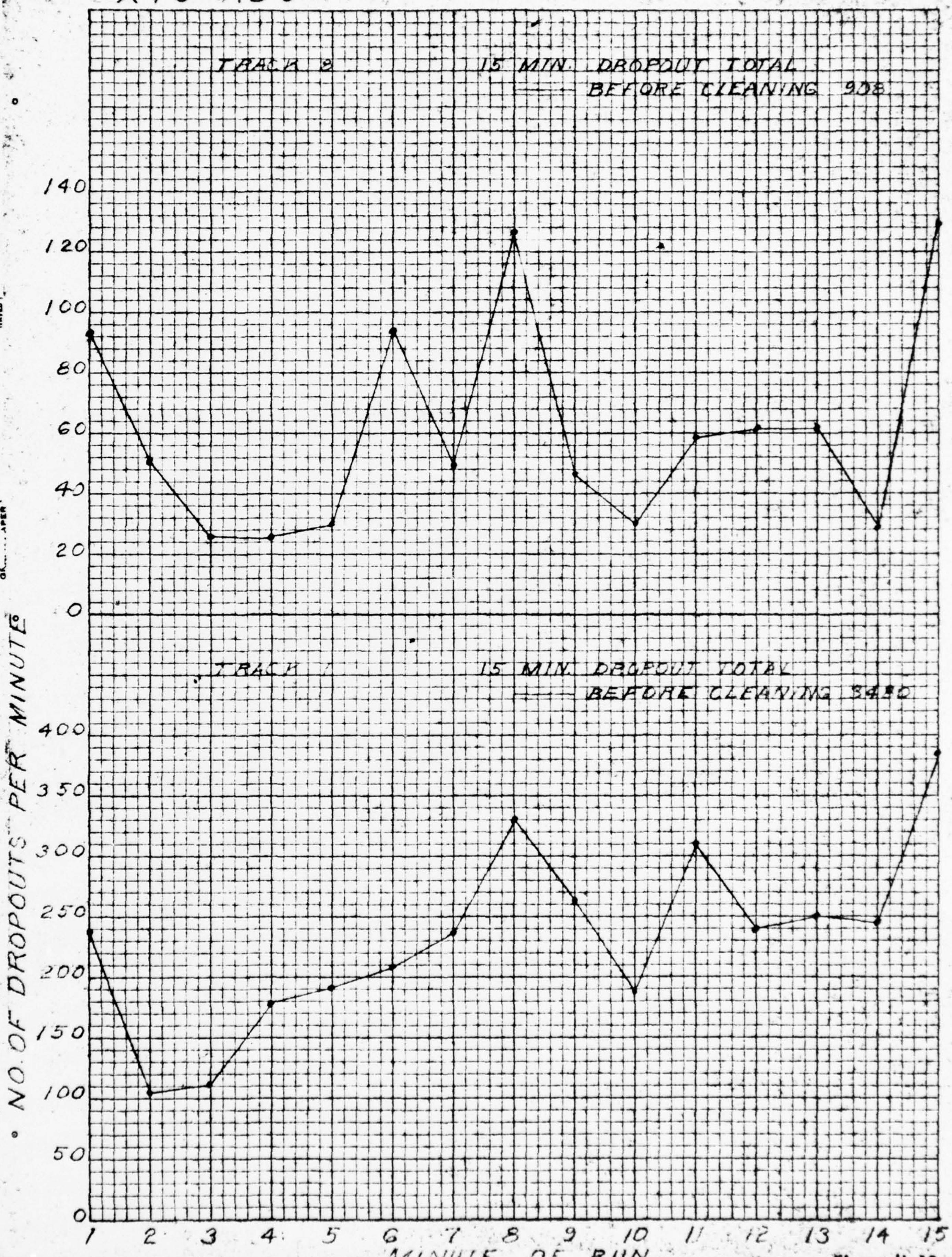


Figure II-10

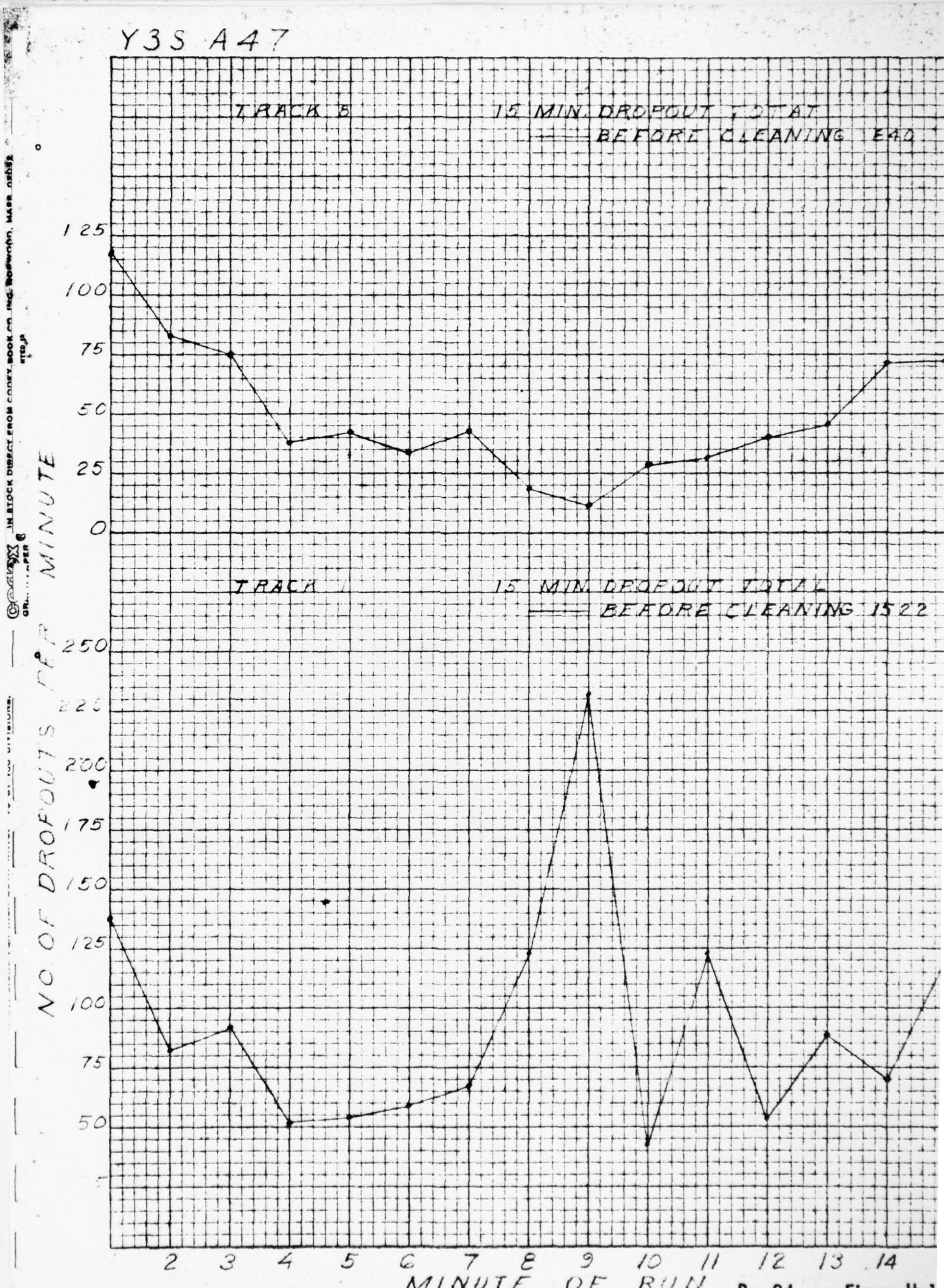

Y3S A47
TRACK 5
15 MIN. DROPOUT
BEFORE CLEANING
TRACK 1
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 1522
NO OF DROPOUTS PER MINUTE
MINUTE OF RUN

Figure II-1

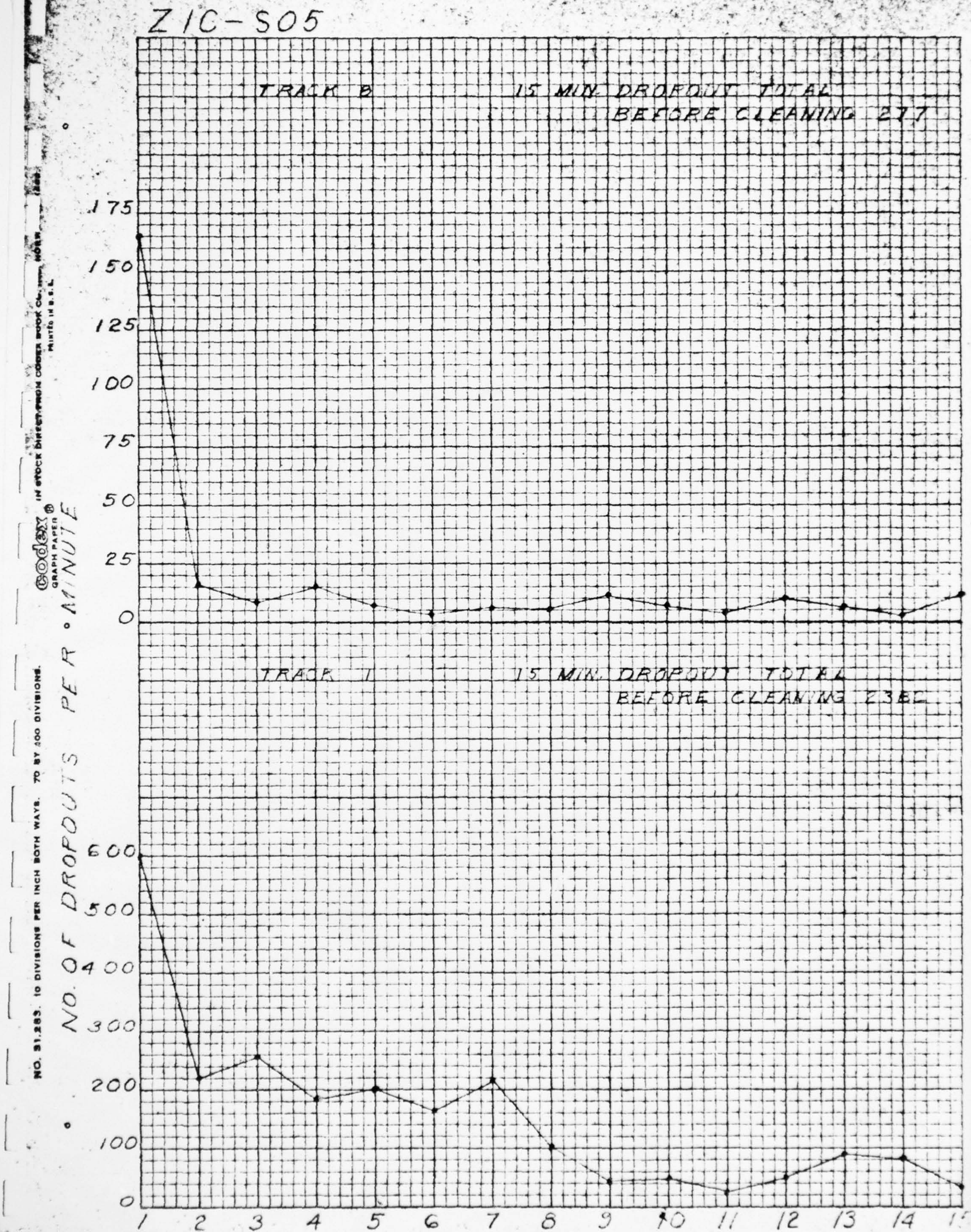
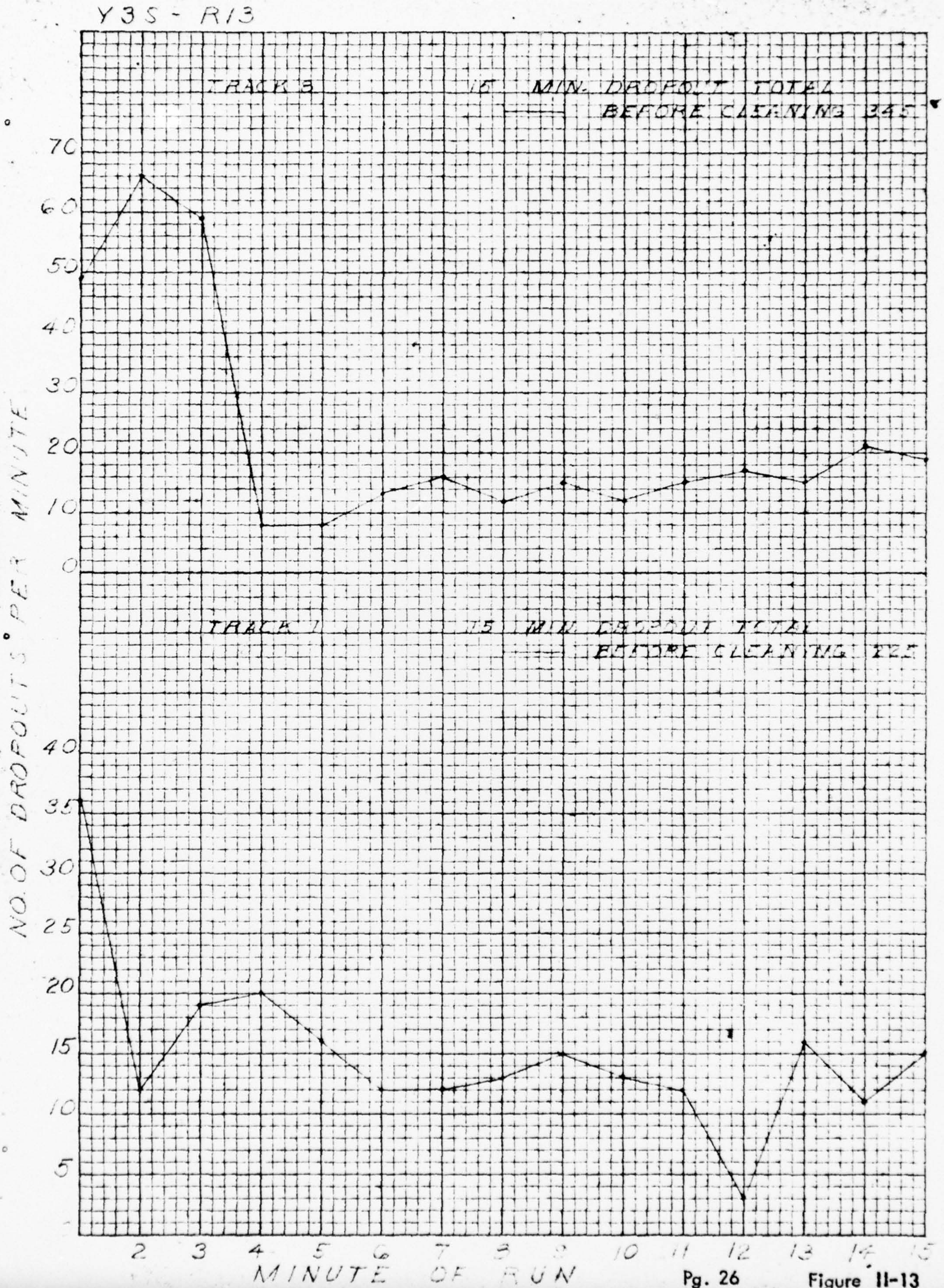

ZIC-S05
TRACK B
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 277
TRACK 1
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 23EC
NO. OF DROPOUTS PER MINUTE
0
25
50
75
100
125
150
175
0
100
200
300
400
500
600
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
MINUTE OF RUN
NO. 31,283. 10 DIVISIONS PER INCH BOTH WAYS. 70 BY 100 DIVISIONS.
Codex GRAPH PAPER

Figure II-12



Y3S - R13
TRACK 3
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 345
TRACK 1
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 225
NO. OF DROPOUTS PER MINUTE
MINUTE OF RUN
70
60
50
40
30
20
10
0
40
35
30
25
20
15
10
5
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Figure II-13

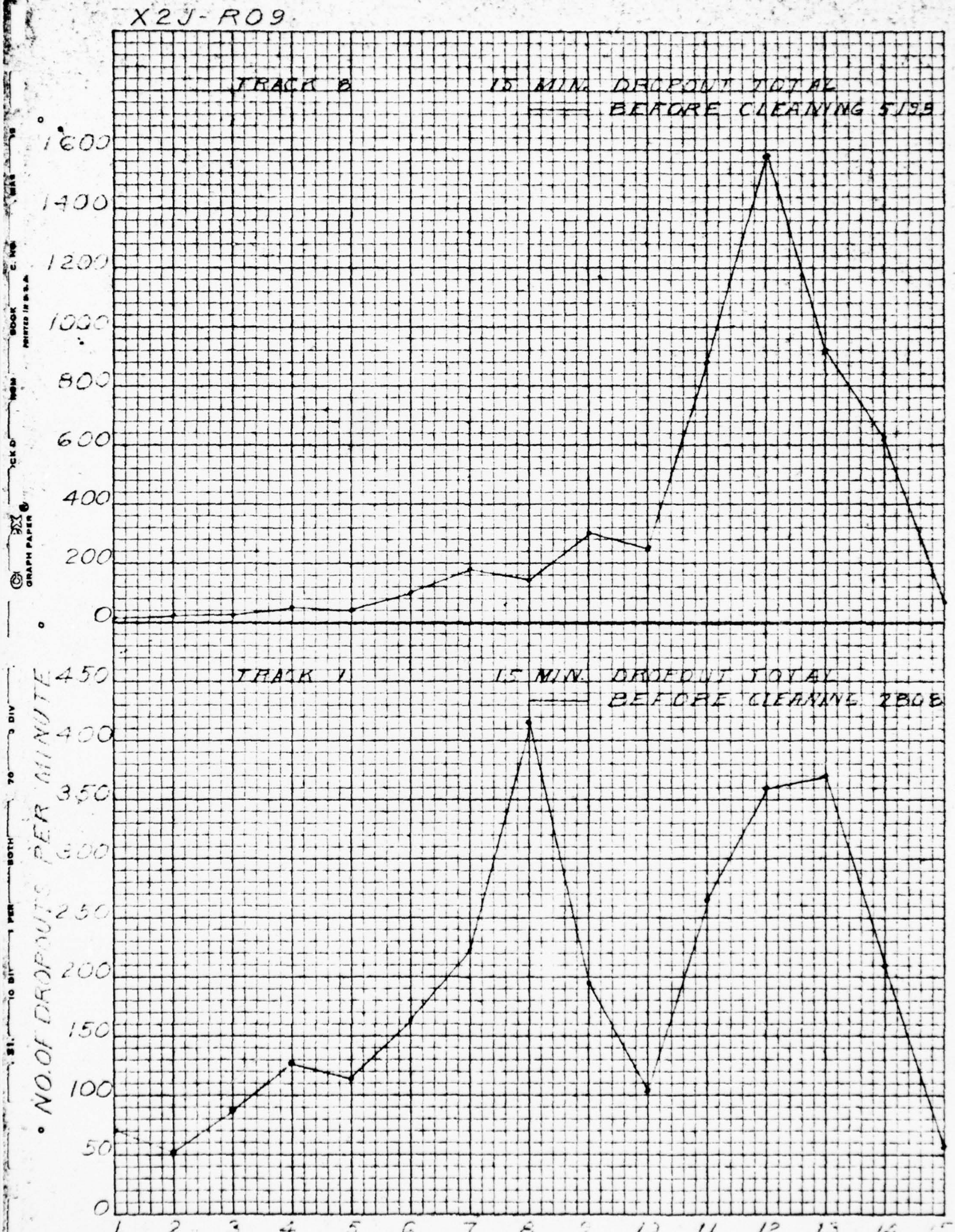
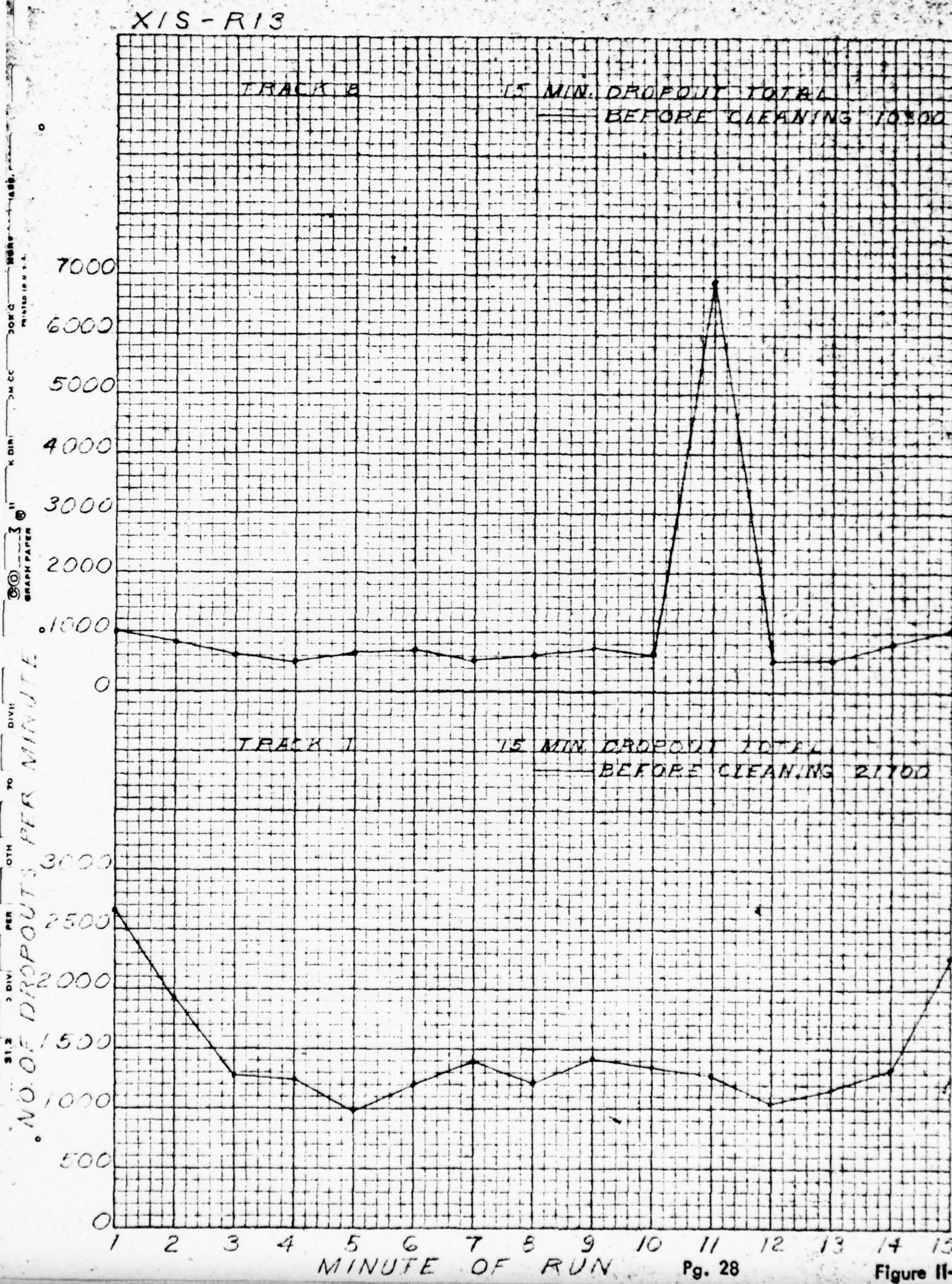

X2J-R09
TRACK 8
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 5199
TRACK 7
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 2808
NO. OF DROPOUTS PER MINUTE
MINUTE OF RUN

Figure II-14



X/S-R13
TRACK 8
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 10300
TRACK 1
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 21700
NO. OF DROPOUTS PER MINUTE
MINUTE OF RUN

Figure II-15

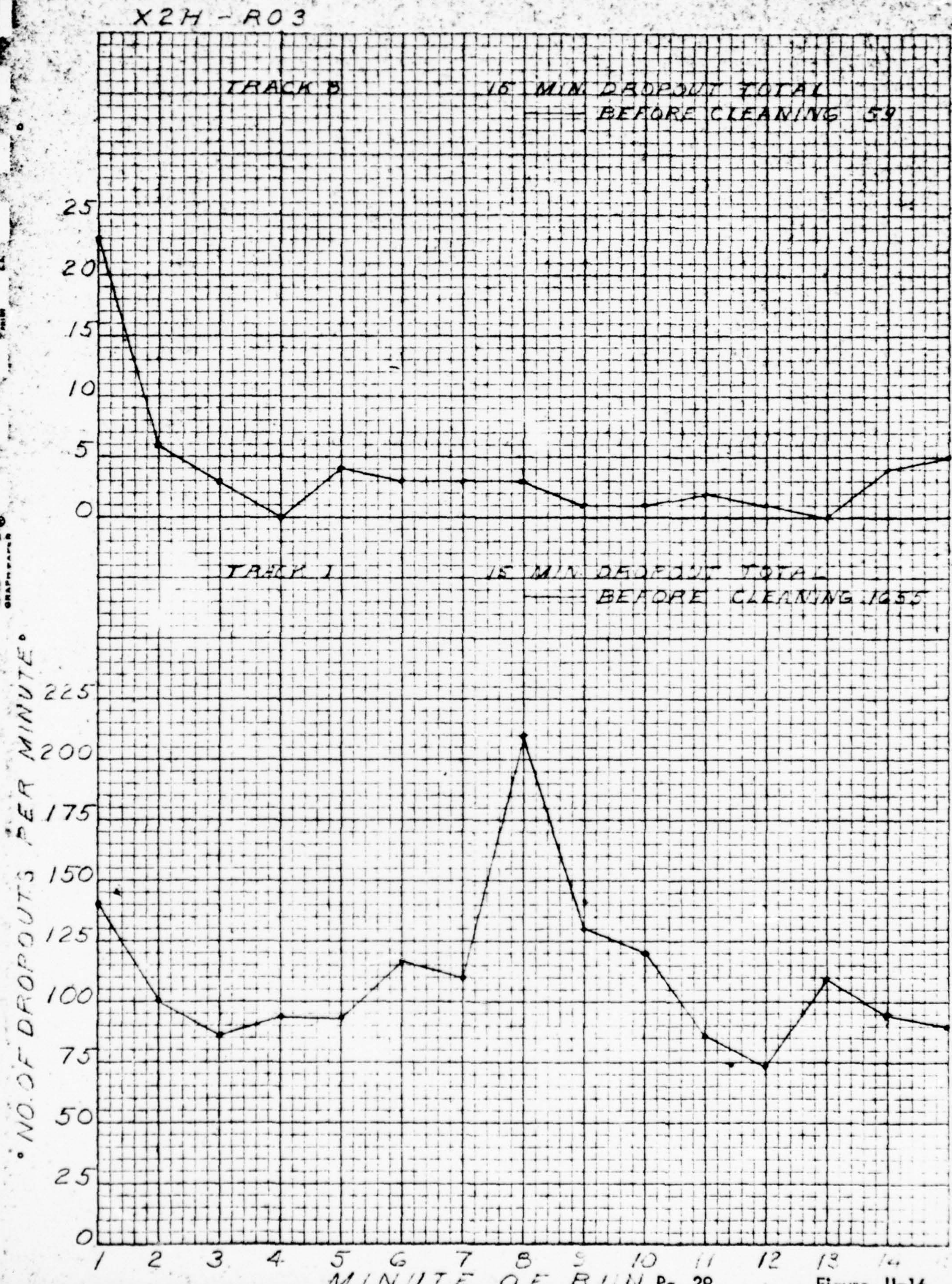

X2H - R03
TRACK 8
15 MIN DROPOUT TOTAL BEFORE CLEANING 59
TRACK 1
15 MIN DROPOUT TOTAL BEFORE CLEANING 1055
NO. OF DROPOUTS PER MINUTE
25
20
15
10
5
0
225
200
175
150
125
100
75
50
25
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
MINUTE OF RUN

Figure II-16

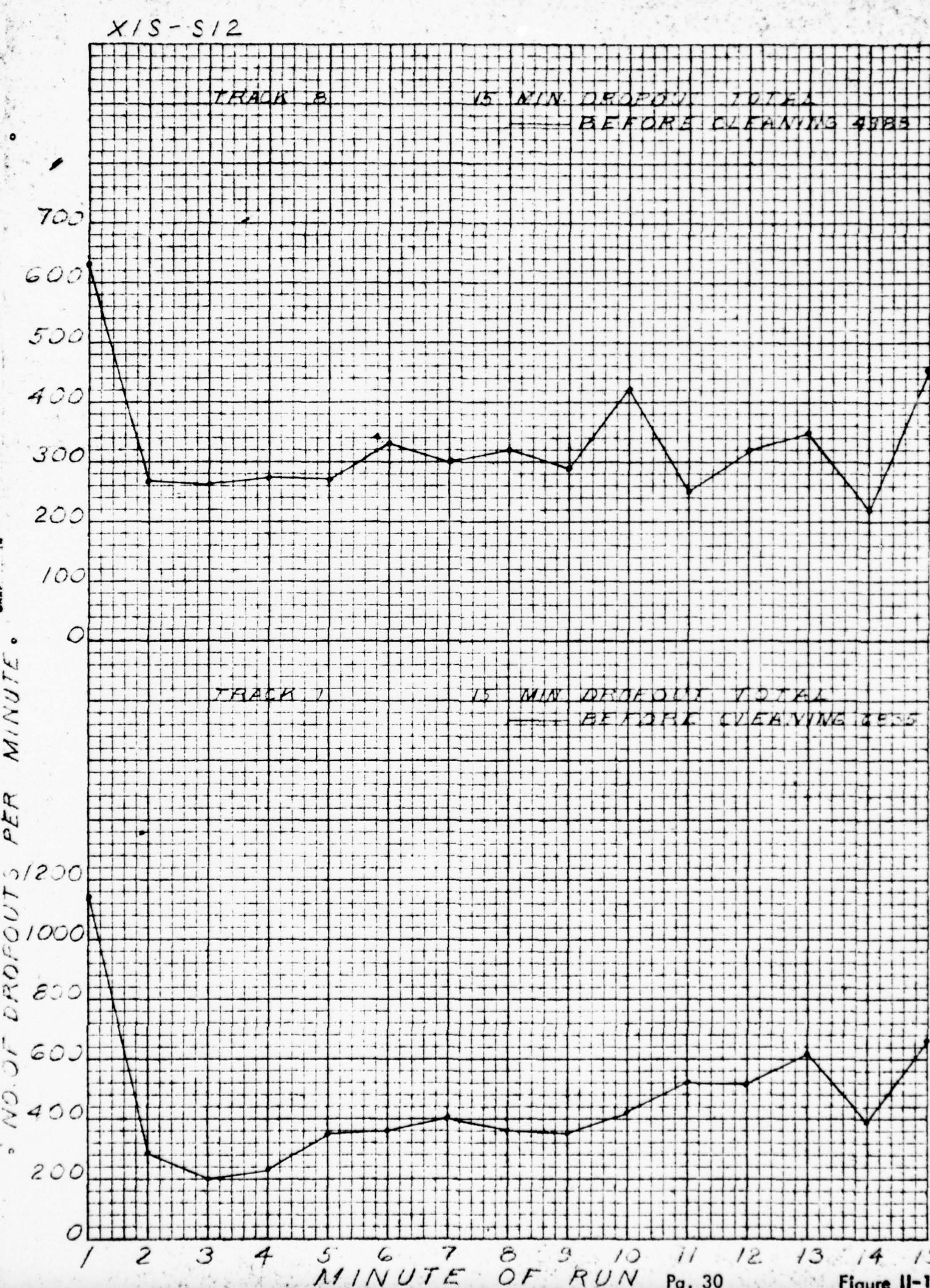
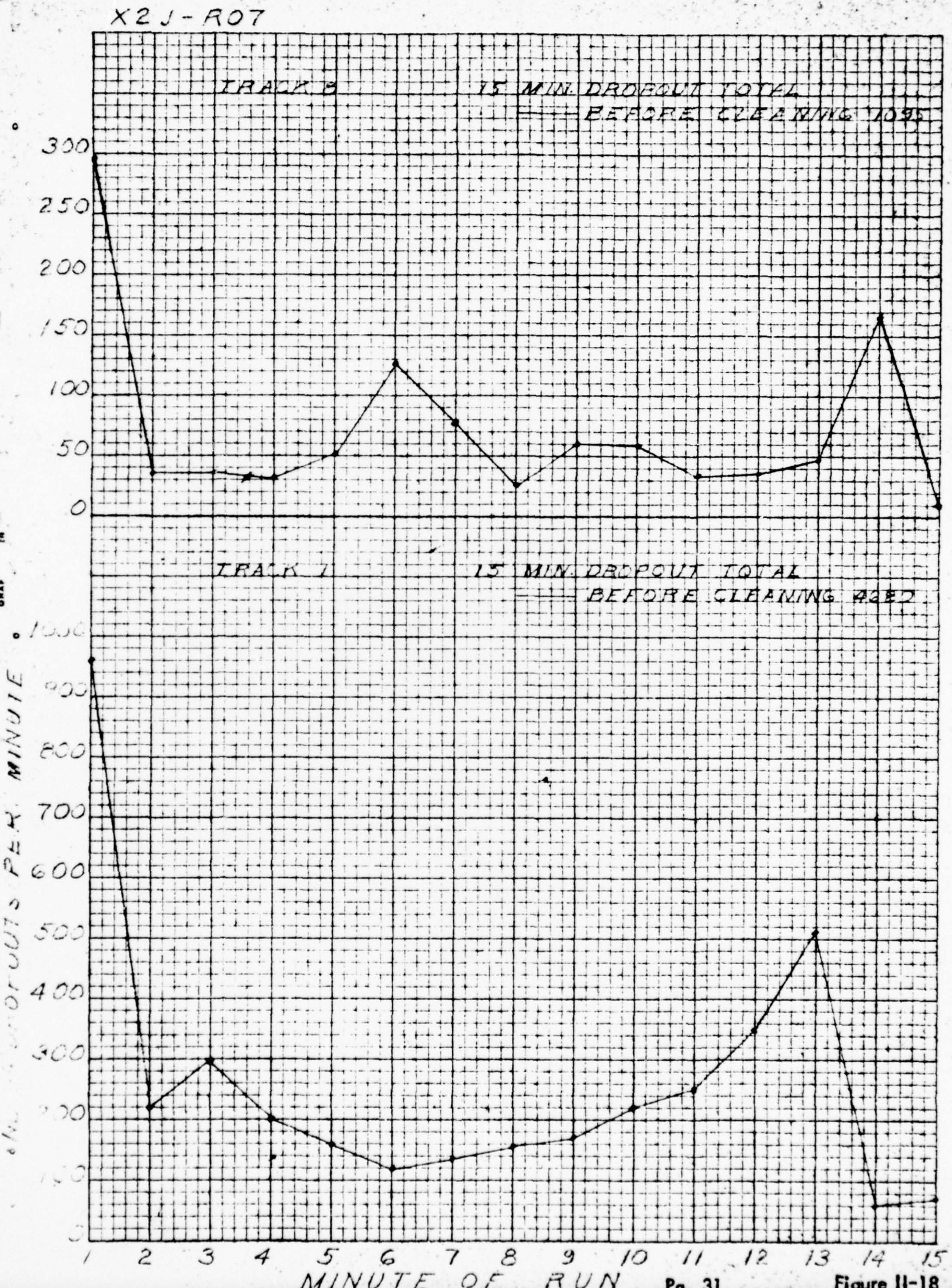

X1S-S12
TRACK 8
15 MIN DROPOUT TOTAL
BEFORE CLEANING 4385
TRACK 7
15 MIN DROPOUT TOTAL
BEFORE CLEANING
NO. OF DROPOUTS PER MINUTE
MINUTE OF RUN
0
100
200
300
400
500
600
700
0
200
400
600
800
1000
1200
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Figure II-17



X2J-R07
TRACK 8
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 1095
TRACK 1
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 4280
DROPOUTS PER MINUTE
MINUTE OF RUN

Figure II-18

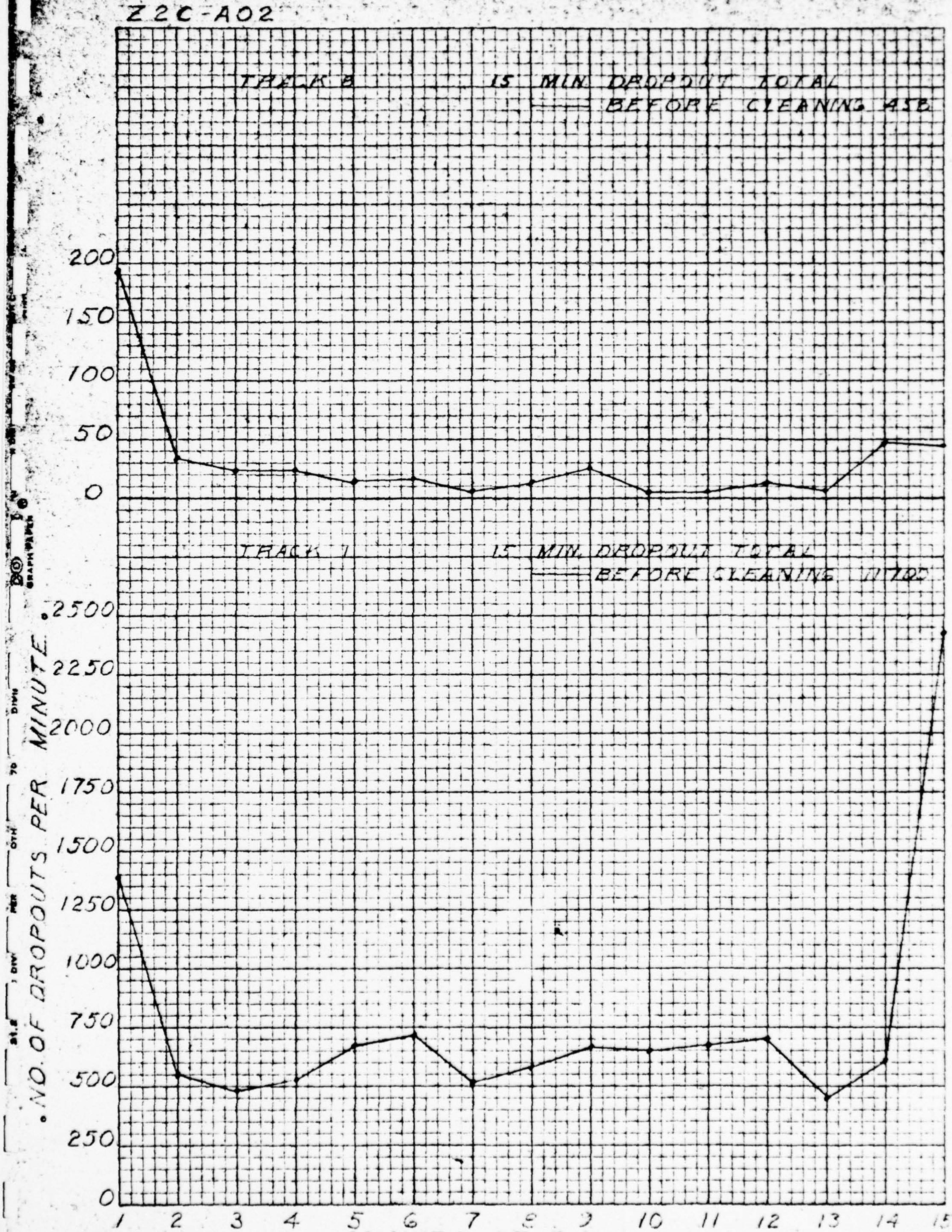

Z2C-A02
TRACK 8
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 458
200
150
100
50
0
TRACK 1
15 MIN. DROPOUT TOTAL
BEFORE CLEANING
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
NO. OF DROPOUTS PER MINUTE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
MINUTE OF RUN

Figure II-19


XIF-A16
15 MIN DROPOUT TOTAL
BEFORE CLEANING
TRACK 7
15 MIN.
600
500
400
300
200
100
0
1500
1250
1000
750
500
250
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
MINUTE OF RUN
NO. OF DROPOUTS PER MINUTE

Figure II-20

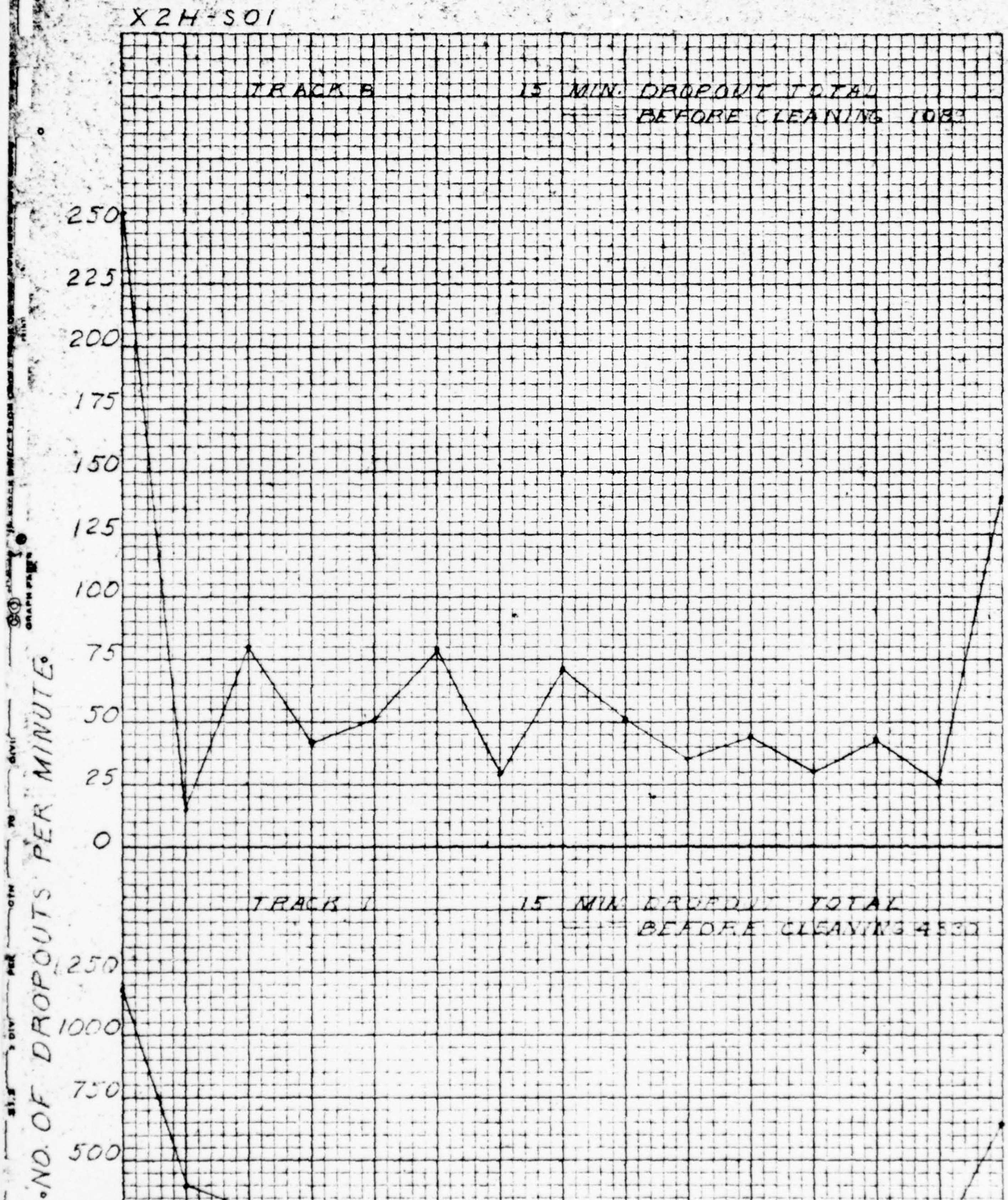

X2H-S01
TRACK B
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 108
TRACK 1
15 MIN DROPOUT TOTAL
BEFORE CLEANING 4530
NO. OF DROPOUTS PER MINUTE
MINUTE OF RUN
0
25
50
75
100
125
150
175
200
225
250
0
250
500
750
1000
1250
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Figure II-21

ZIC-A62
TRACK 8
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 397
TRACK 1
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 2745
175
150
125
100
75
50
25
0
700
600
500
400
300
200
100
0
NO. OF DROPOUTS PER MINUTE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
MINUTE OF RUN

Figure II-22

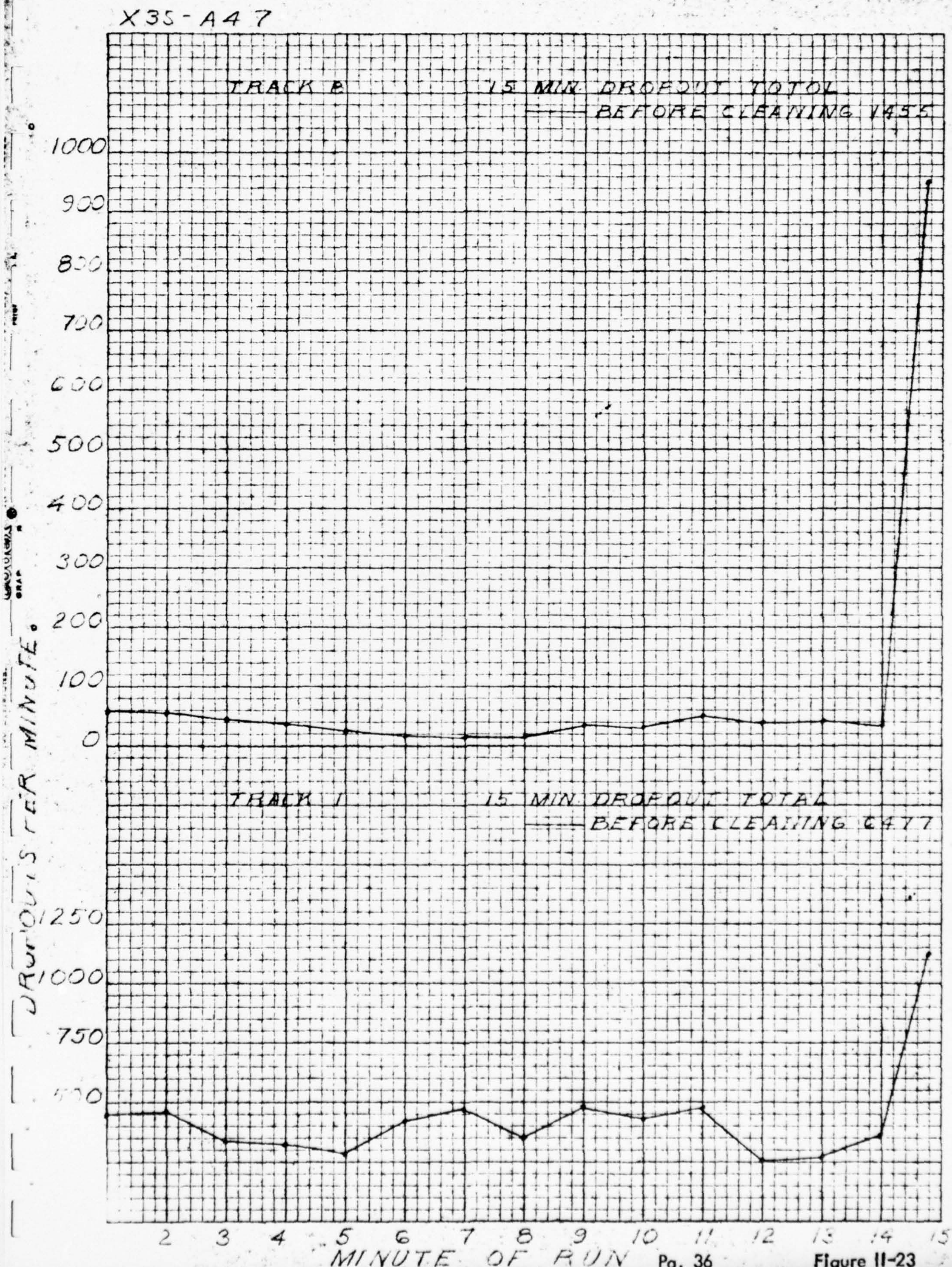

X35-A47
TRACK 8
15 MIN DROPOUT TOTAL
BEFORE CLEANING 1455
TRACK 1
15 MIN DROPOUT TOTAL
BEFORE CLEANING 6477
DROPOUTS PER MINUTE
MINUTE OF RUN
1000
900
800
700
600
500
400
300
200
100
0
1250
1000
750
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Figure II-23

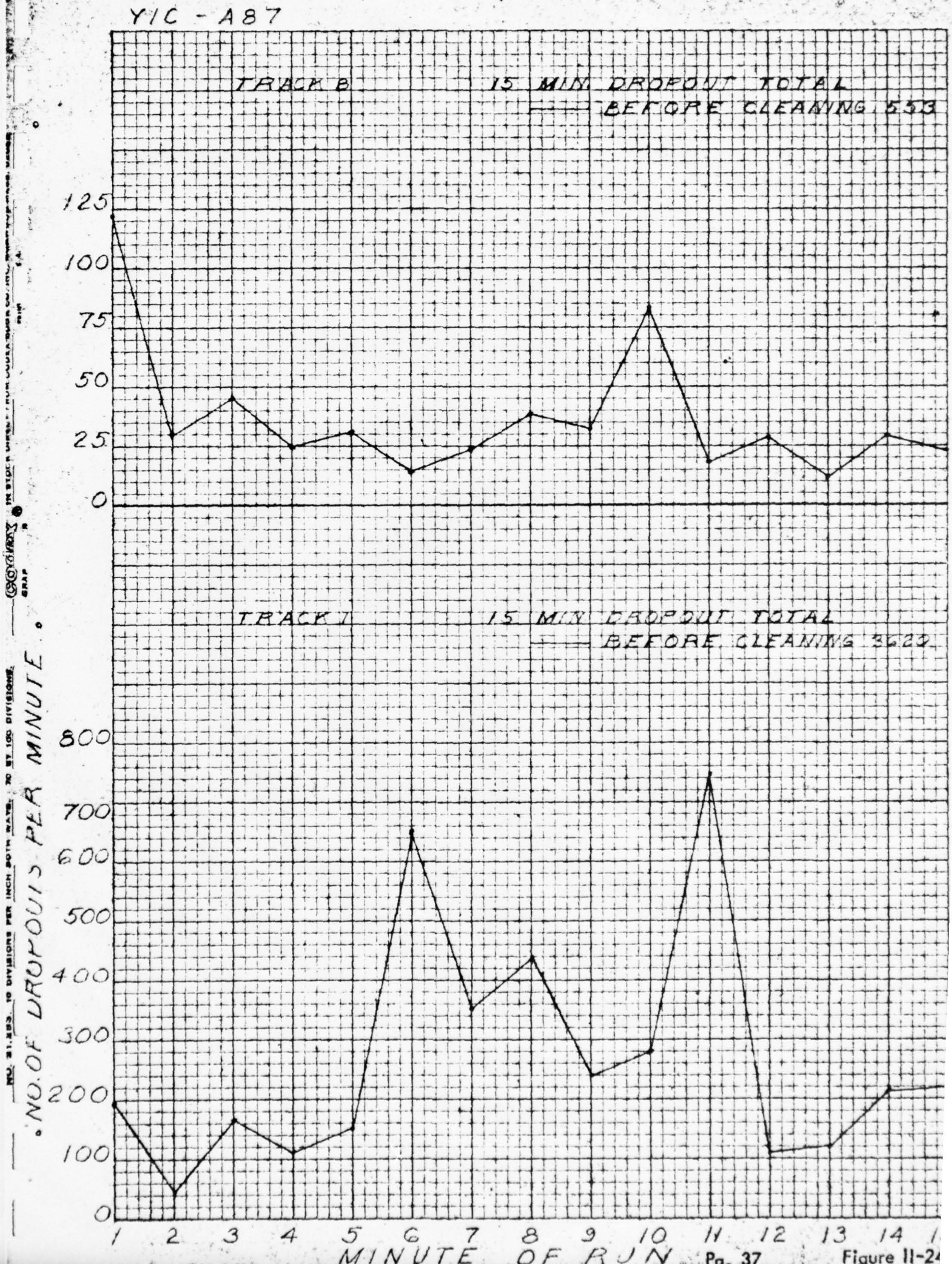

YIC - A87
TRACK B
15 MIN DROPOUT TOTAL
BEFORE CLEANING 553
125
100
75
50
25
0
TRACK 1
15 MIN DROPOUT TOTAL
BEFORE CLEANING 3620
800
700
600
500
400
300
200
100
0
NO. OF DROPOUTS PER MINUTE
1 2 3 4 5 6 7 8 9 10 11 12 13 14
MINUTE OF RUN

Figure II-24

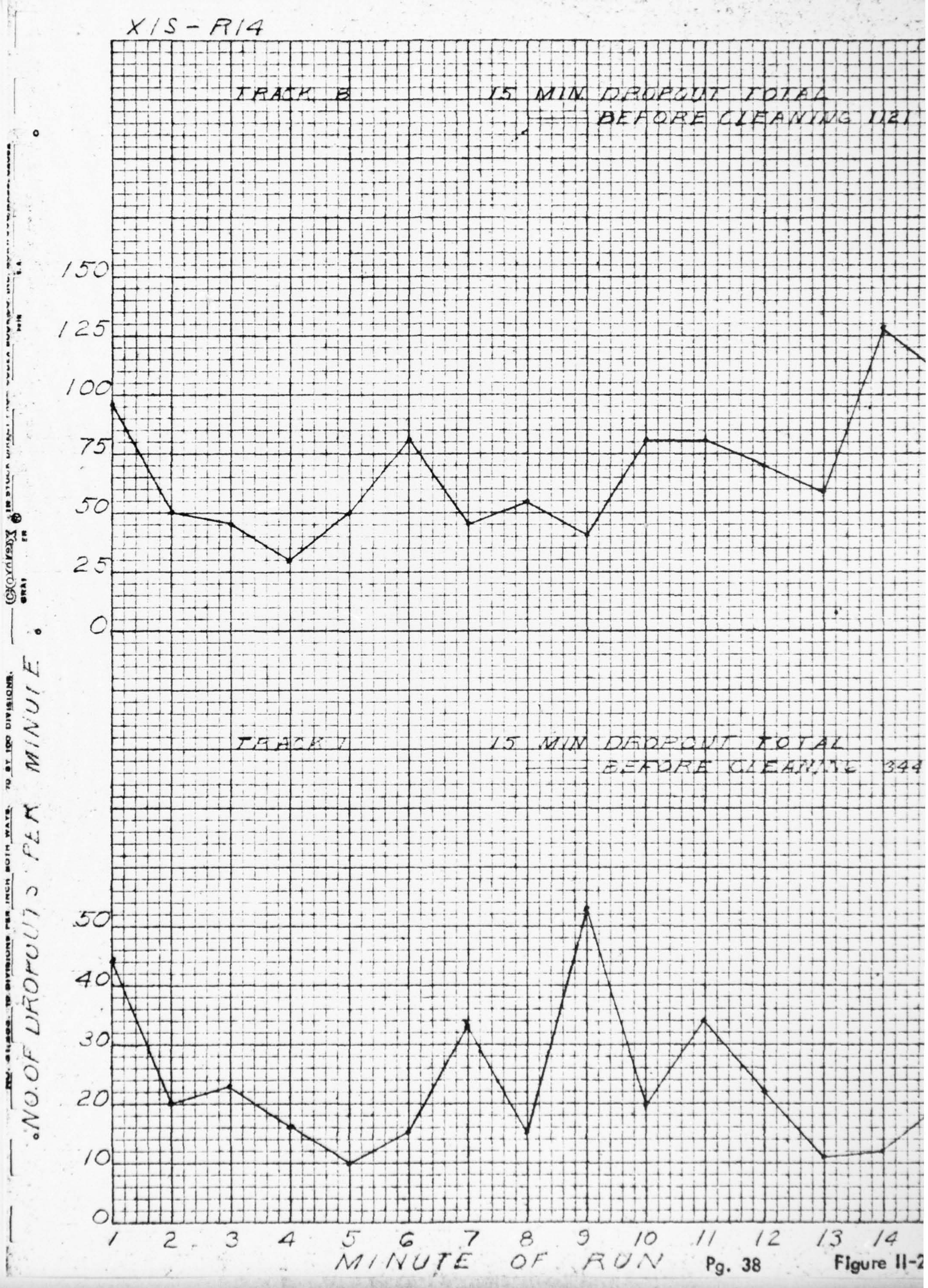

X/S - R14
TRACK 8
15 MIN DROPOUT TOTAL
BEFORE CLEANING 1121
TRACK 7
15 MIN DROPOUT TOTAL
BEFORE CLEANING 344
NO. OF DROPOUTS PER MINUTE
MINUTE OF RUN

Figure II-2

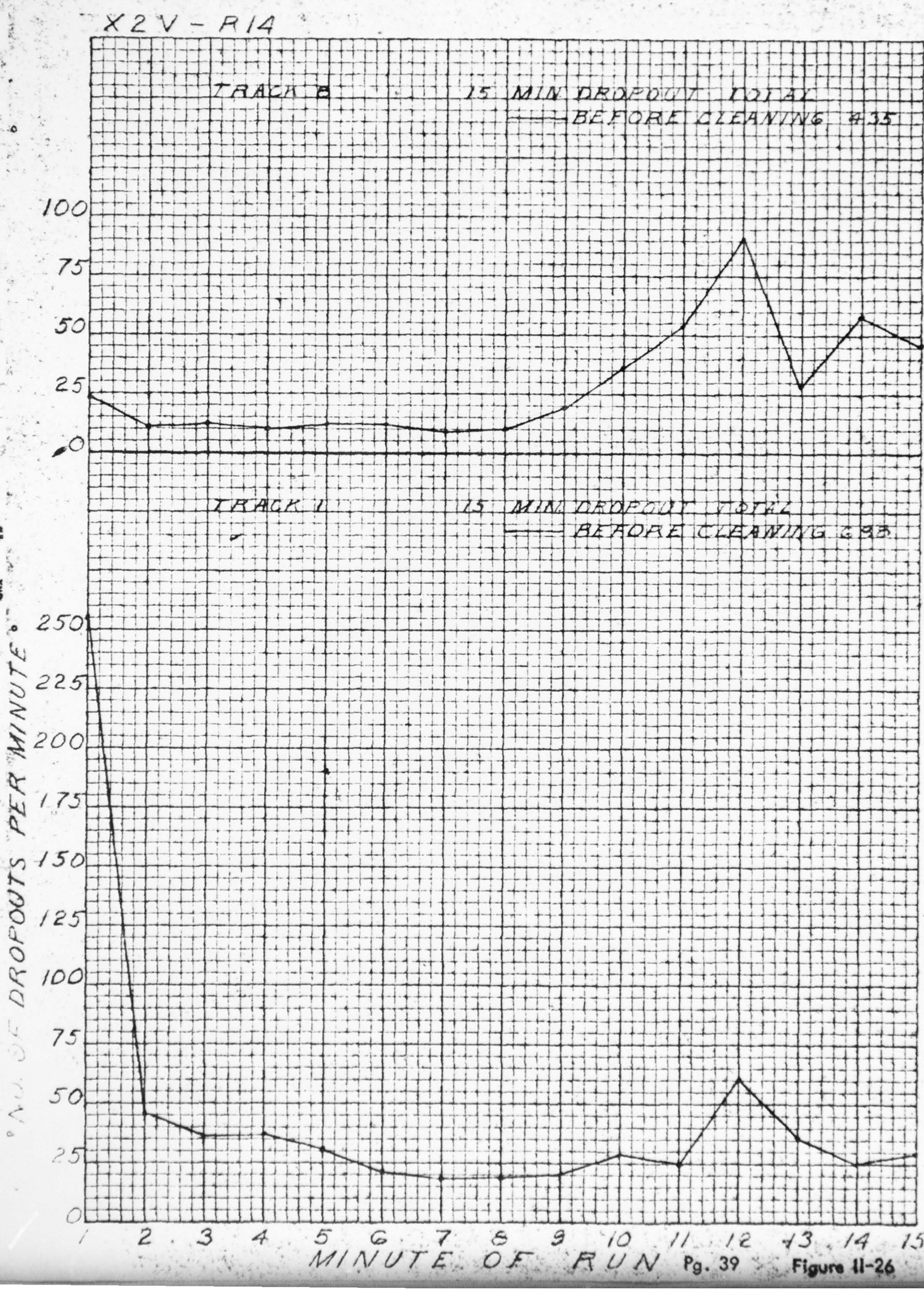
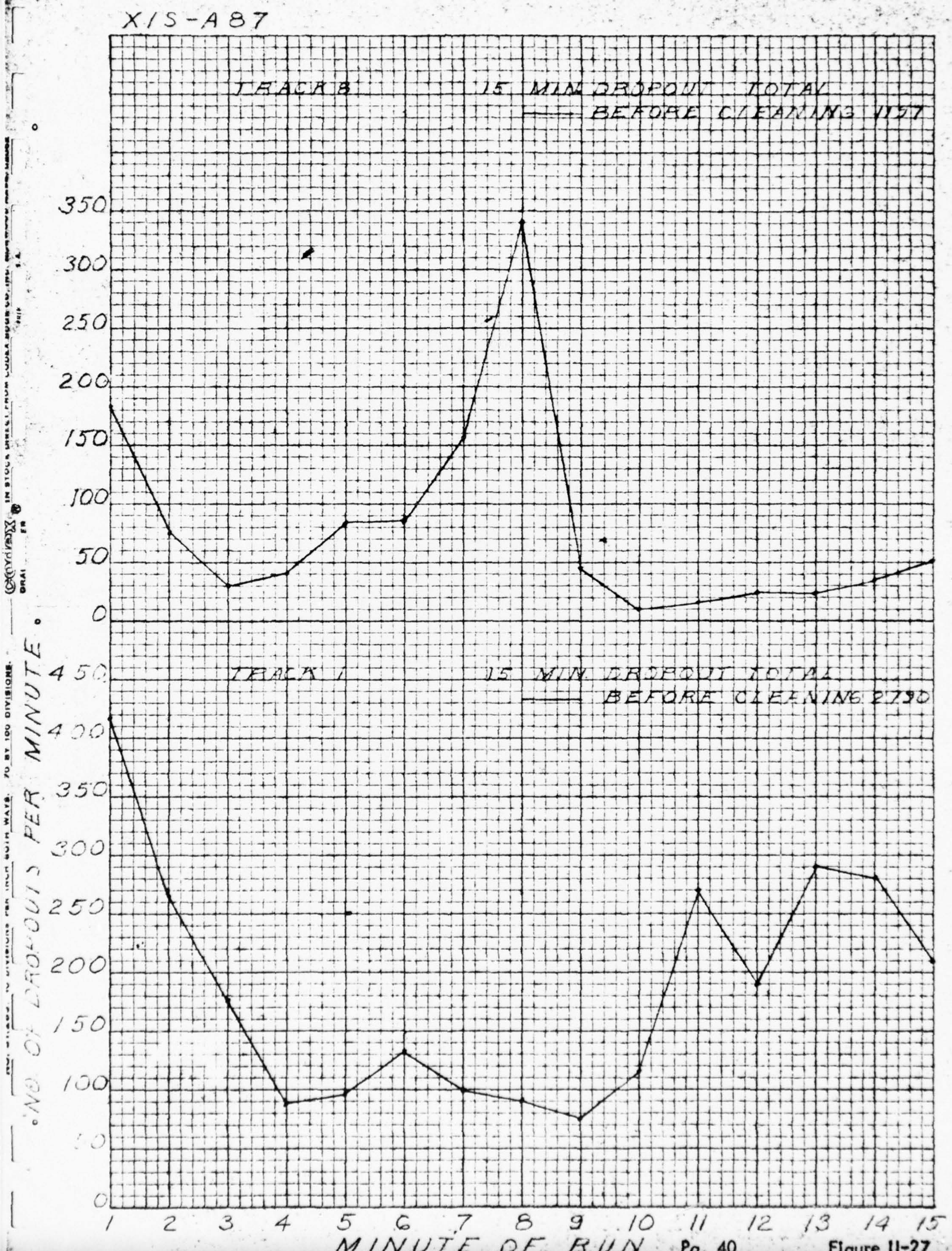

X2V - R14
TRACK 8
15 MIN DROPOUT TOTAL
BEFORE CLEANING 435
TRACK 1
15 MIN DROPOUT TOTAL
BEFORE CLEANING 633
NO. OF DROPOUTS PER MINUTE
MINUTE OF RUN

Figure II-26



X/S-A87
TRACK 8
15 MIN DROPOUT TOTAL
BEFORE CLEANING 1157
350
300
250
200
150
100
50
0
TRACK 1
15 MIN DROPOUT TOTAL
BEFORE CLEANING 2790
450
400
350
300
250
200
150
100
50
0
NO. OF DROPOUTS PER MINUTE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
MINUTE OF RUN

Figure II-27

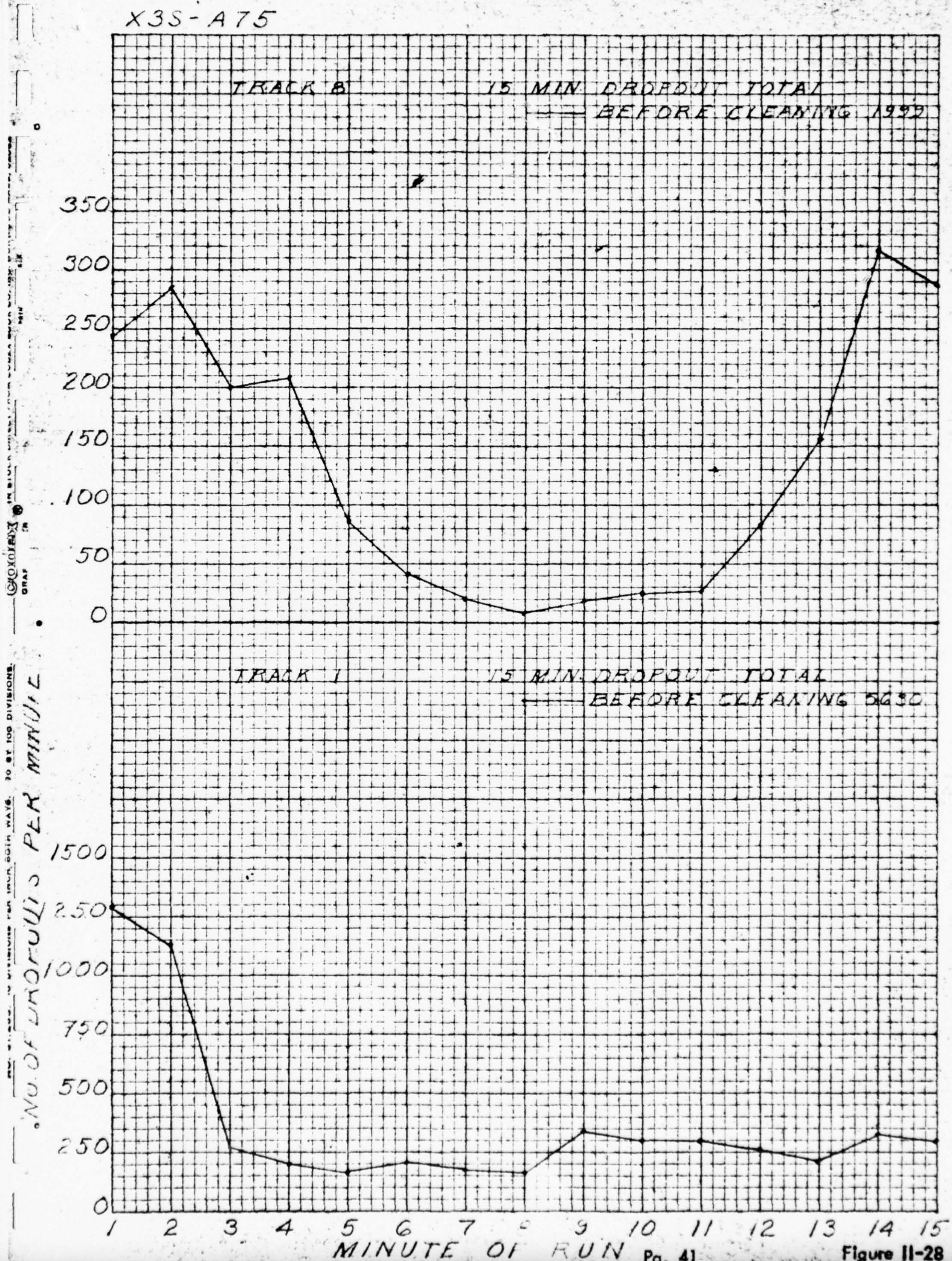

X3S-A75
TRACK 8
15 MIN DROPOUT TOTAL
BEFORE CLEANING 1992
350
300
250
200
150
100
50
0
TRACK 1
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 5630
1500
1250
1000
750
500
250
0
NO. OF DROPOUTS PER MINUTE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
MINUTE OF RUN

Figure II-28

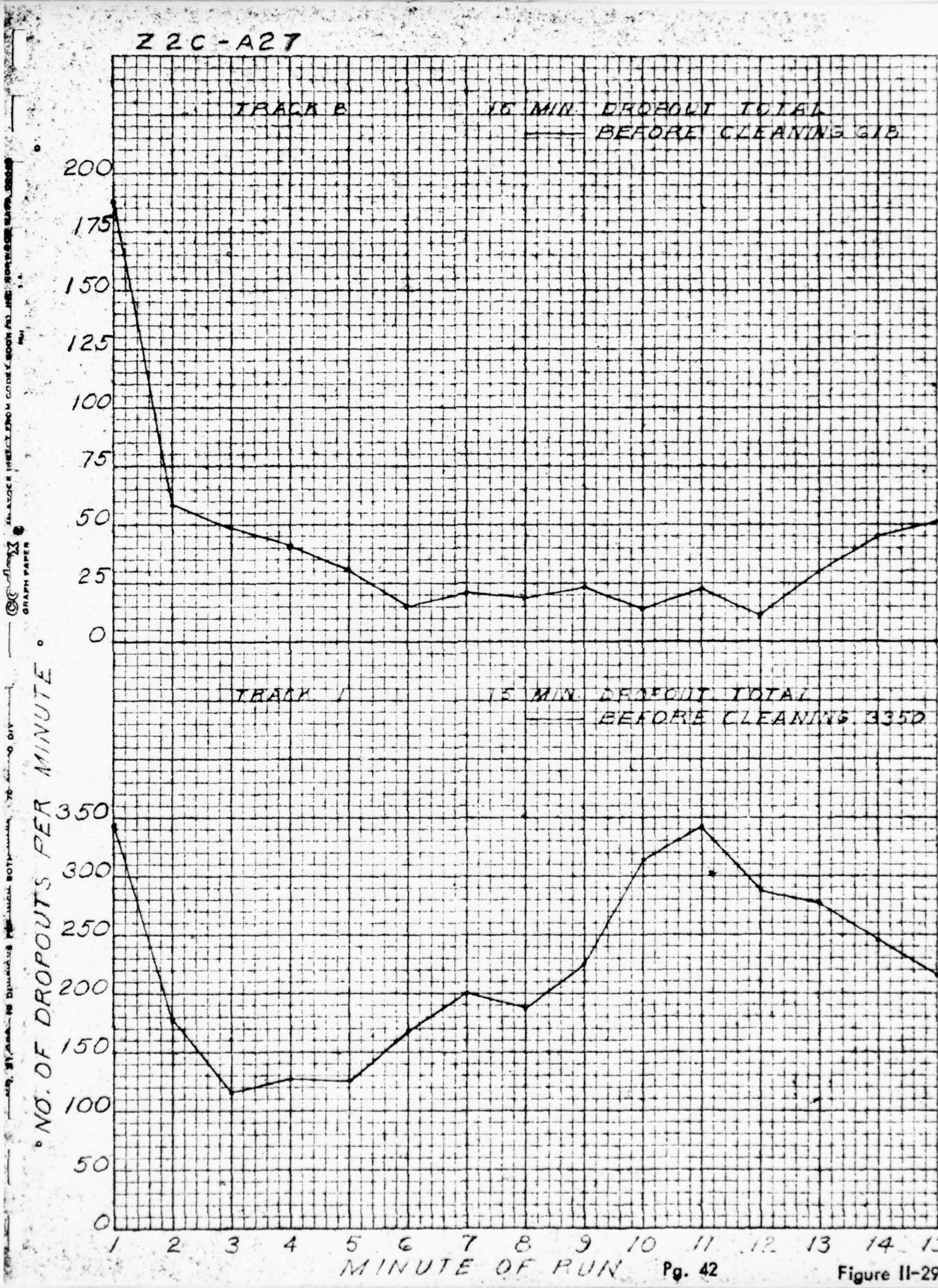

Z2C-A27
TRACK 8
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 618
TRACK 1
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 3350
NO. OF DROPOUTS PER MINUTE
MINUTE OF RUN

Figure II-29

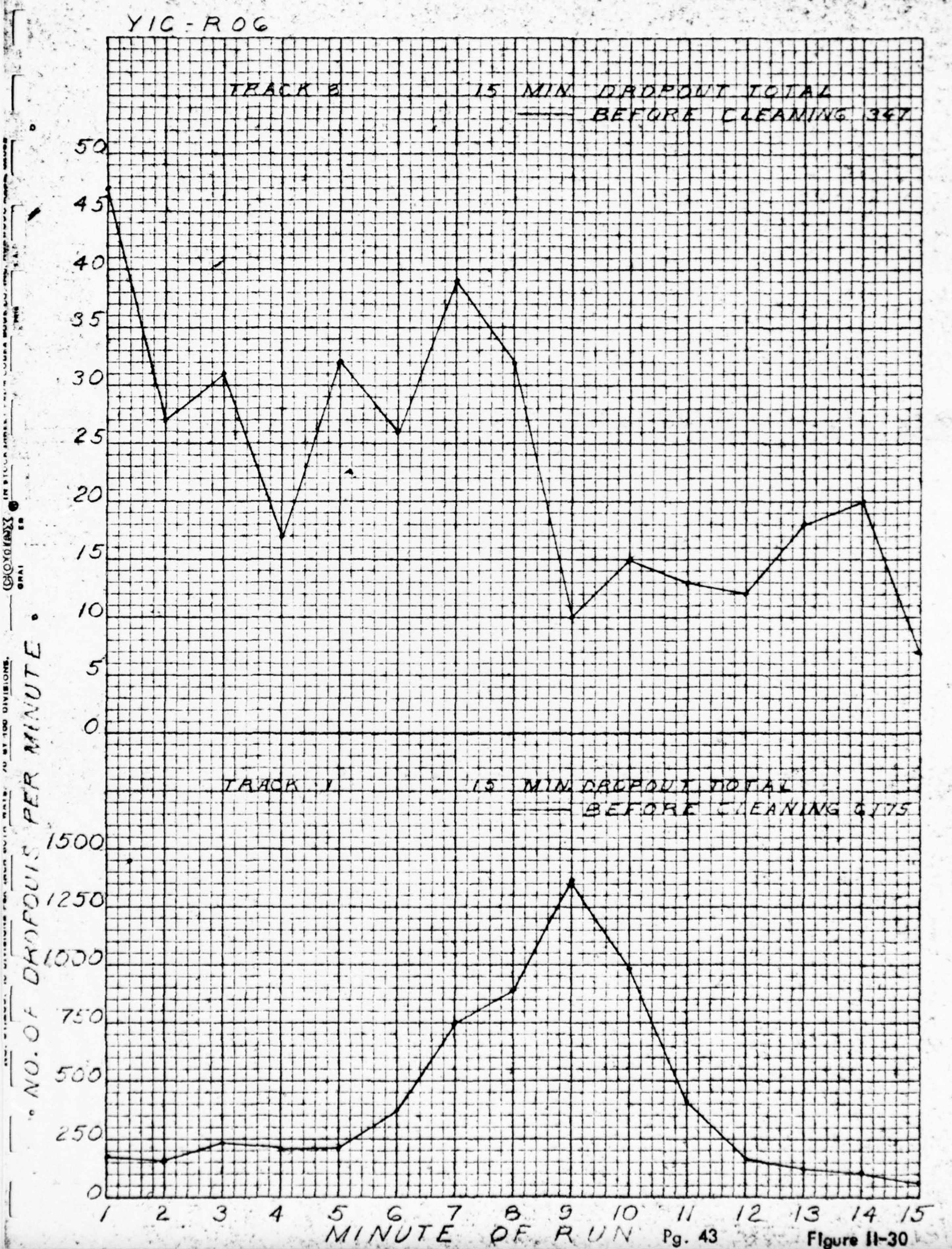

YIC-R06
TRACK 8
15 MIN DROPOUT TOTAL
BEFORE CLEANING 347
TRACK 1
15 MIN DROPOUT TOTAL
BEFORE CLEANING 6175
NO. OF DROPOUTS PER MINUTE
MINUTE OF RUN
0
5
10
15
20
25
30
35
40
45
50
250
500
750
1000
1250
1500
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Figure II-30

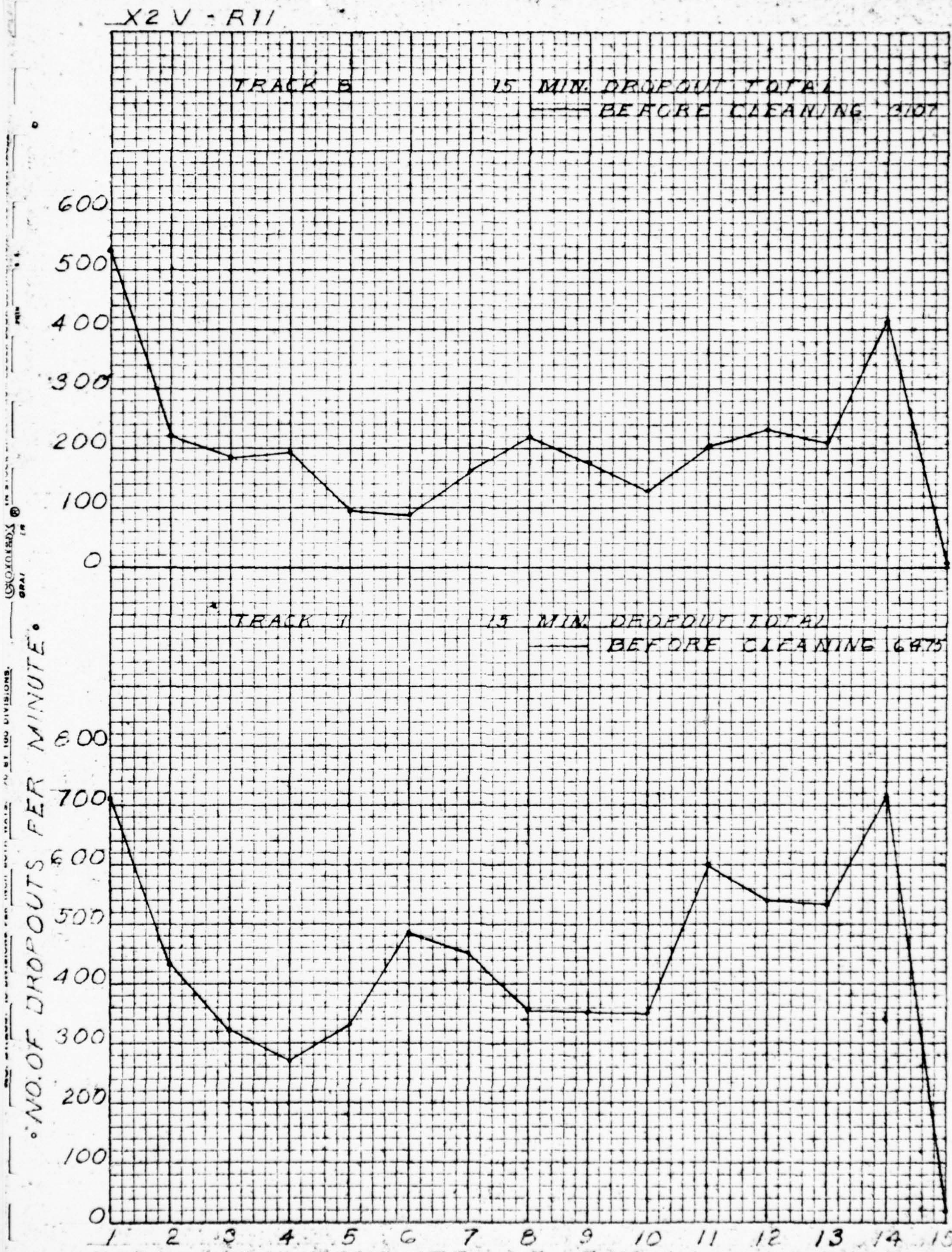

X2 V - R11
TRACK 8
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 3107
TRACK 7
15 MIN. DROPOUT TOTAL
BEFORE CLEANING 6875
NO. OF DROPOUTS PER MINUTE
600
500
400
300
200
100
0
800
700
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
MINUTE OF RUN

Figure II-31

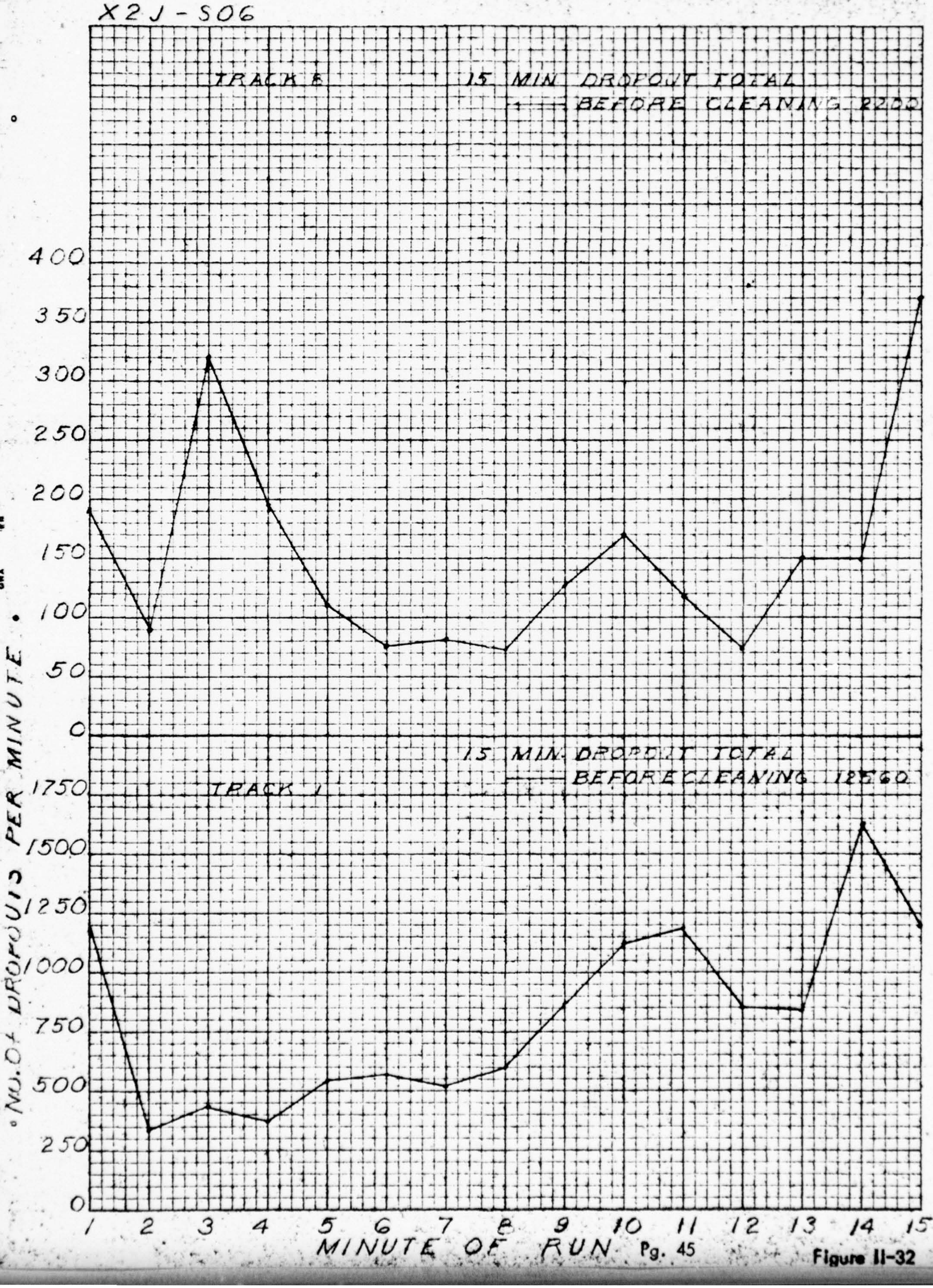
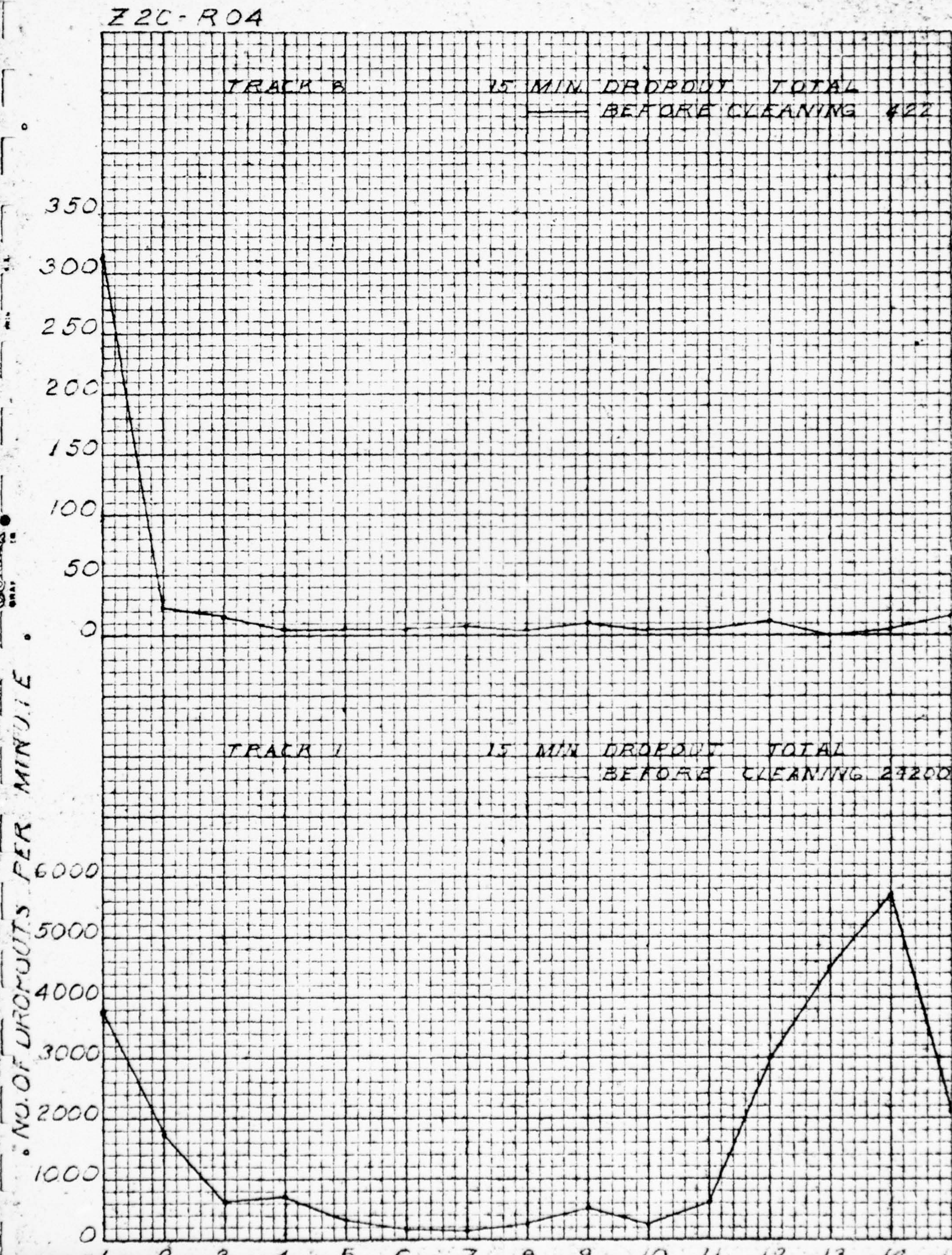
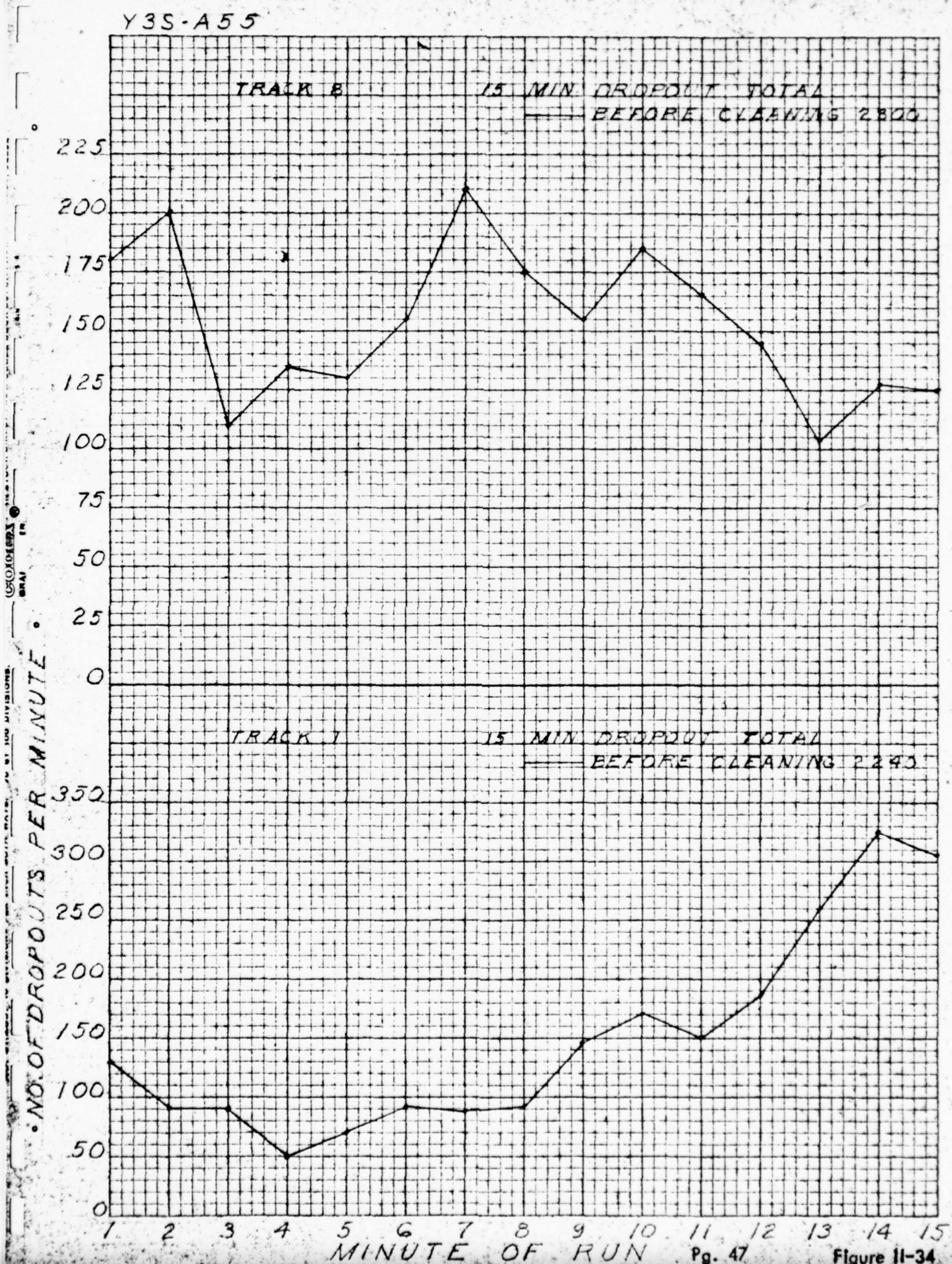

X2J-S06
TRACK 8
15 MIN DROPOUT TOTAL
BEFORE CLEANING 2200
TRACK 1
15 MIN DROPOUT TOTAL
BEFORE CLEANING 12560
NO. OF DROPOUTS PER MINUTE
MINUTE OF RUN
400
350
300
250
200
150
100
50
0
1750
1500
1250
1000
750
500
250
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Figure II-32



Z2C-R04
TRACK 8
15 MIN DROPOUT TOTAL
BEFORE CLEANING 422
350
300
250
200
150
100
50
0
TRACK 1
15 MIN DROPOUT TOTAL
BEFORE CLEANING 24200
6000
5000
4000
3000
2000
1000
0
NO. OF DROPOUTS PER MINUTE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
MINUTE OF RUN

Figure II-33



Y3S-A55
TRACK 8
15 MIN DROPOUT TOTAL
BEFORE CLEANING 2800
TRACK 7
15 MIN DROPOUT TOTAL
BEFORE CLEANING 2240
NO. OF DROPOUTS PER MINUTE
225
200
175
150
125
100
75
50
25
0
350
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
MINUTE OF RUN

Figure II-34


XIF- A43
TRACK B
15 MIN DROPOUT TOTAL
BEFORE CLEANING 3053
TRACK 1
15 MIN DROPOUT TOTAL
BEFORE CLEANING 4725
NO. OF DROPOUTS PER MINUTE
MINUTE OF RUN
500
450
400
350
300
250
200
150
100
50
0
1500
1250
1000
750
500
250
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Figure II-35

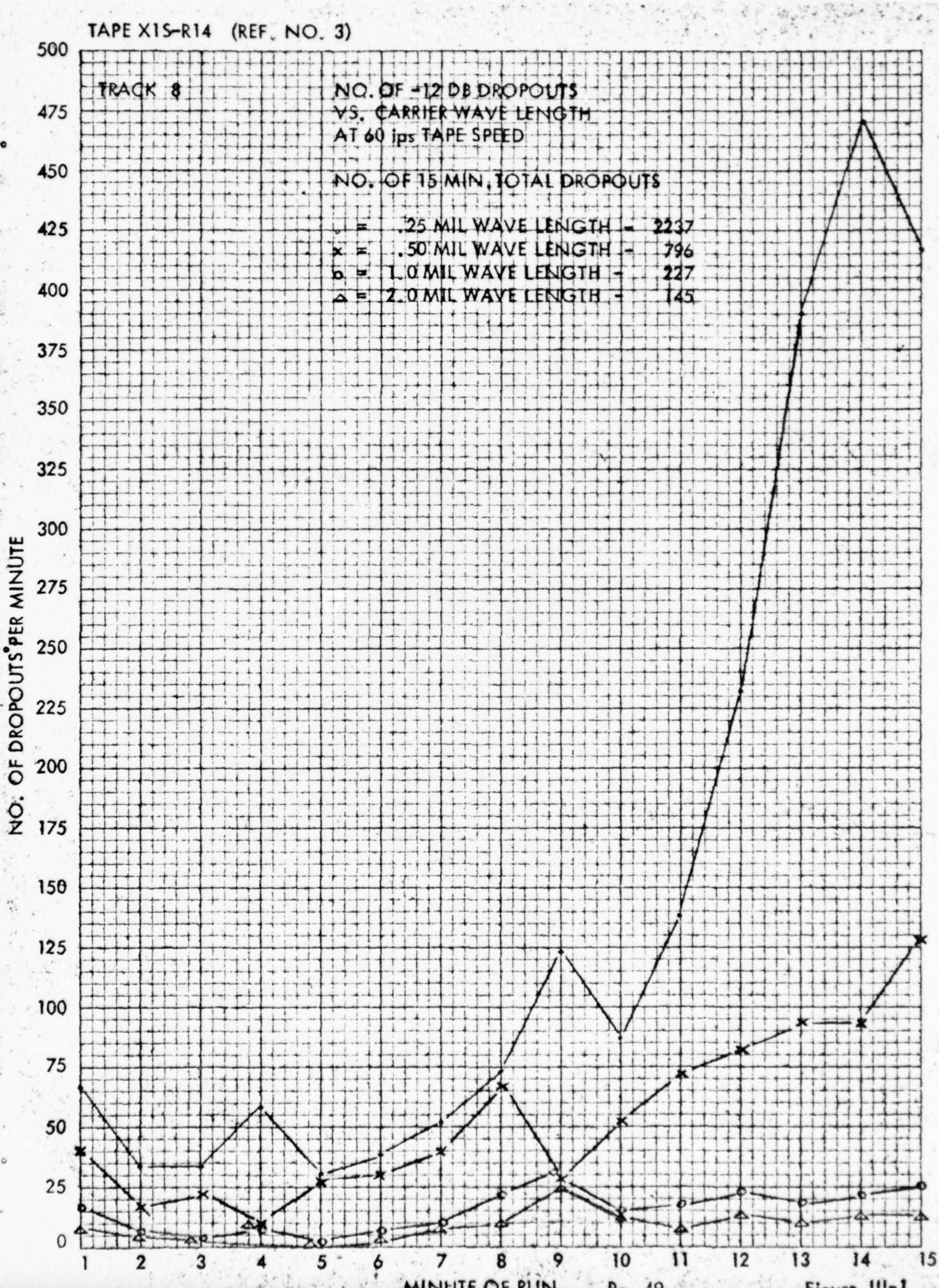

TAPE X1S-R14 (REF. NO. 3)
TRACK 8
NO. OF -12 DB DROPOUTS
VS. CARRIER WAVE LENGTH
AT 60 ips TAPE SPEED
NO. OF 15 MIN. TOTAL DROPOUTS
∘ = .25 MIL WAVE LENGTH - 2237
x = .50 MIL WAVE LENGTH - 796
o = 1.0 MIL WAVE LENGTH - 227
△ = 2.0 MIL WAVE LENGTH - 145
NO. OF DROPOUTS PER MINUTE
500
475
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
MINUTE OF RUN

Figure III-1

TAPE X2V-R14 (REF. No. 6)

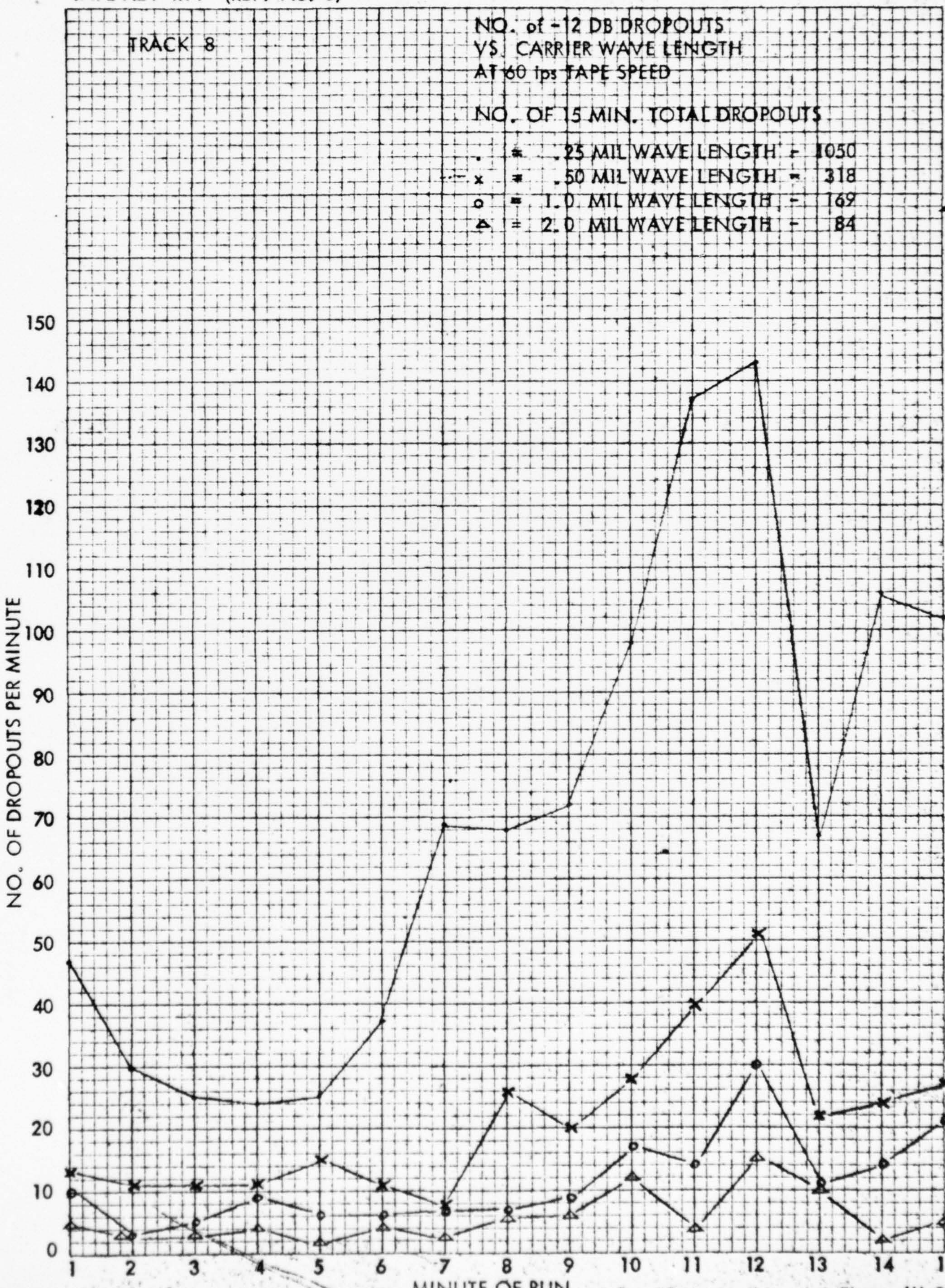
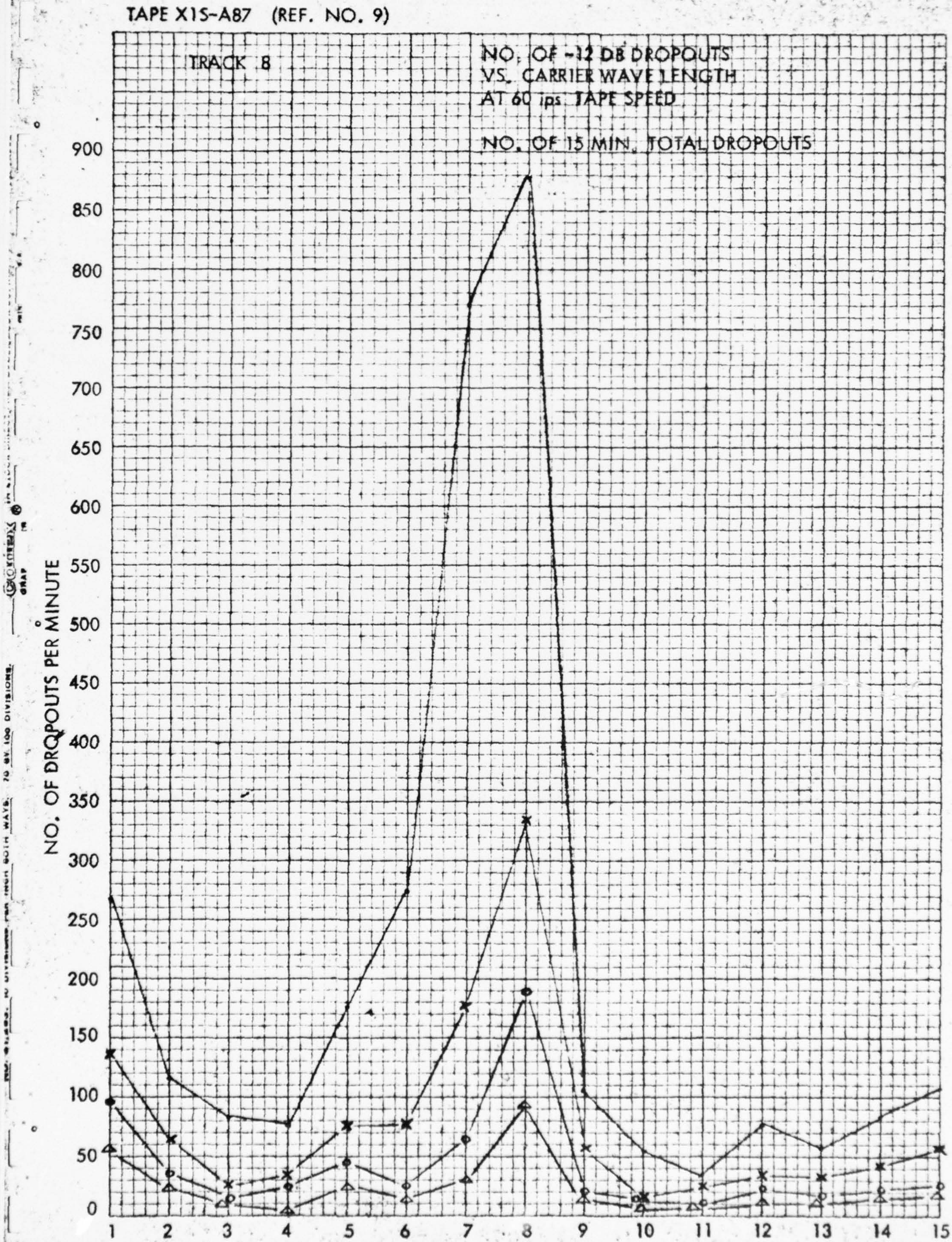


Figure III-2



TAPE X1S-A87 (REF. NO. 9)
TRACK 8
NO. OF -12 DB DROPOUTS
VS. CARRIER WAVE LENGTH
AT 60 ips TAPE SPEED
NO. OF 15 MIN. TOTAL DROPOUTS
NO. OF DROPOUTS PER MINUTE
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
MINUTE OF RUN

Figure III-3

TAPE X3S-A75 (REF. NO. 12)

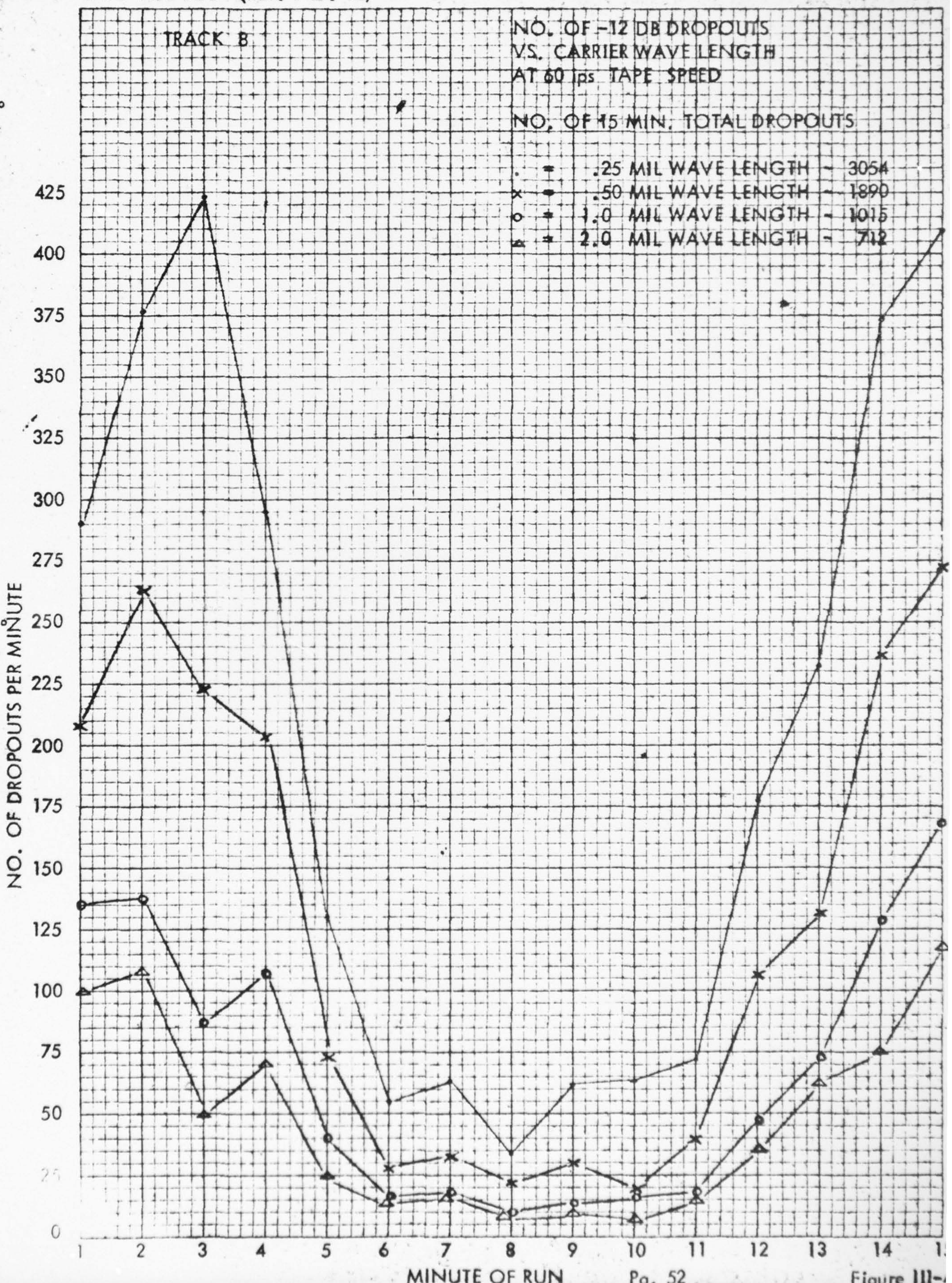


Figure III-

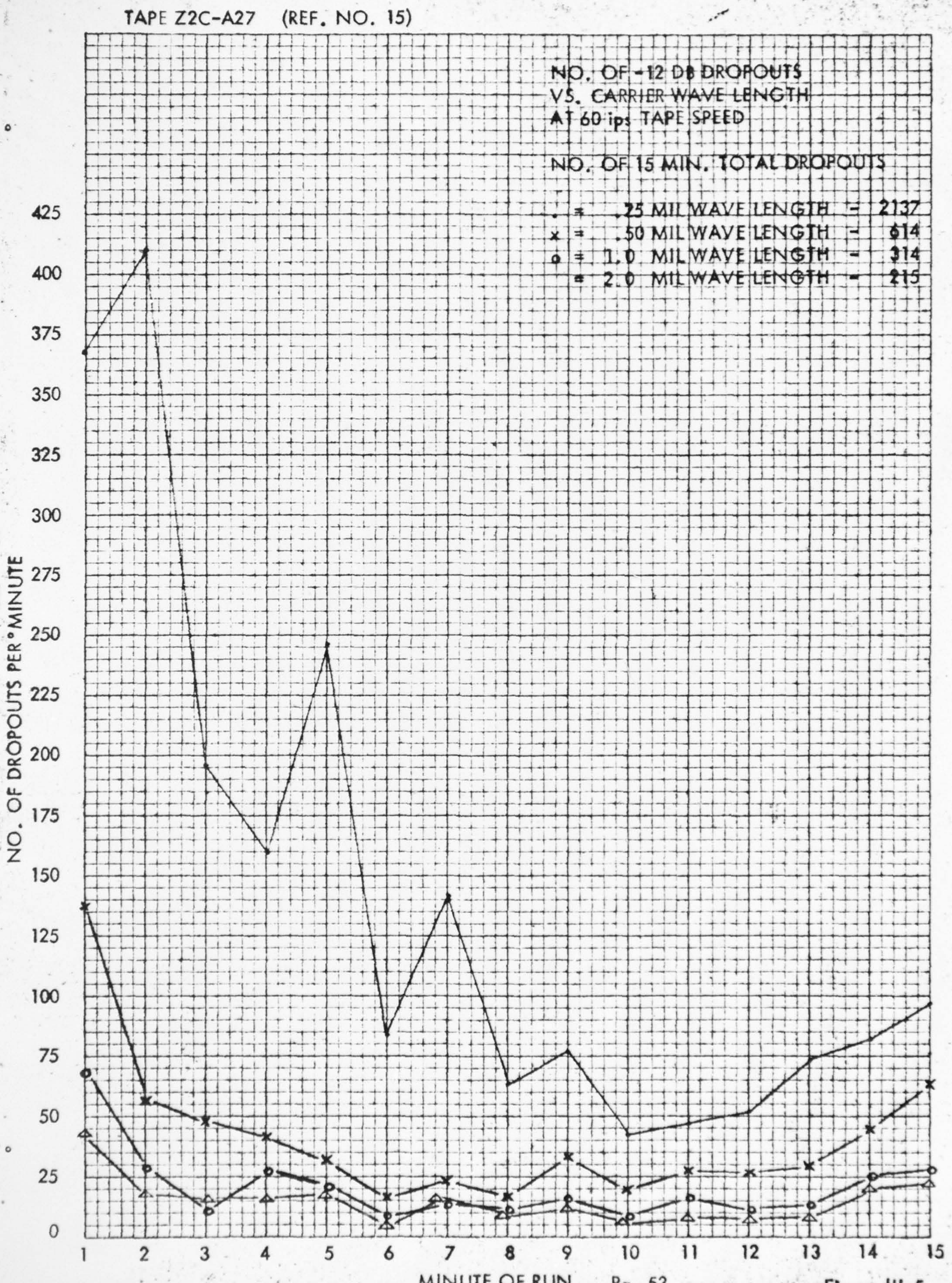

TAPE Z2C-A27 (REF. NO. 15)
NO. OF -12 DB DROPOUTS
VS. CARRIER WAVE LENGTH
AT 60 ips TAPE SPEED
NO. OF 15 MIN. TOTAL DROPOUTS
. = .25 MIL WAVE LENGTH = 2137
x = .50 MIL WAVE LENGTH = 614
o = 1.0 MIL WAVE LENGTH = 314
= 2.0 MIL WAVE LENGTH = 215
NO. OF DROPOUTS PER MINUTE
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
MINUTE OF RUN

Figure III-5

TAPE Y1C-R06 (REF. NO. 18)

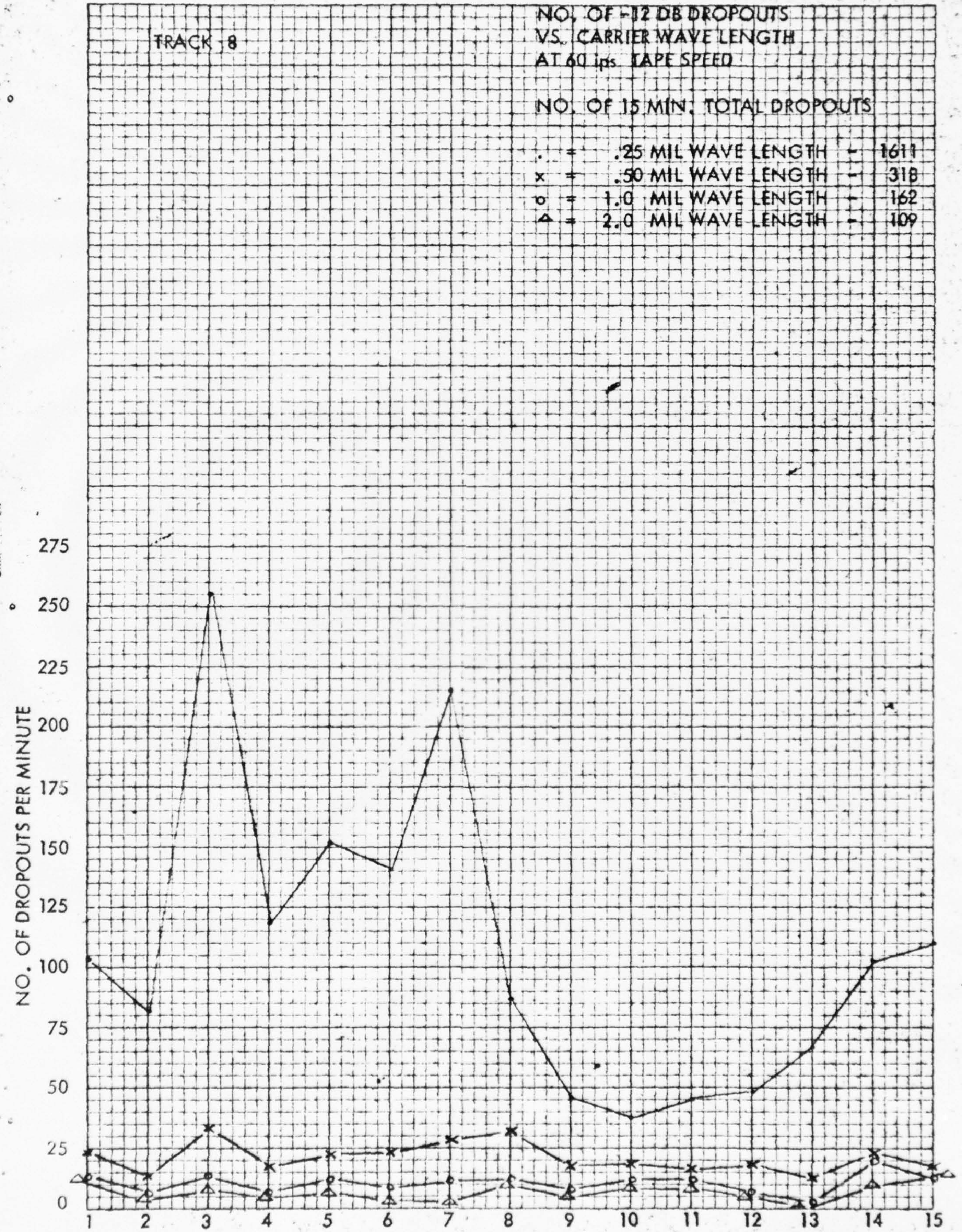
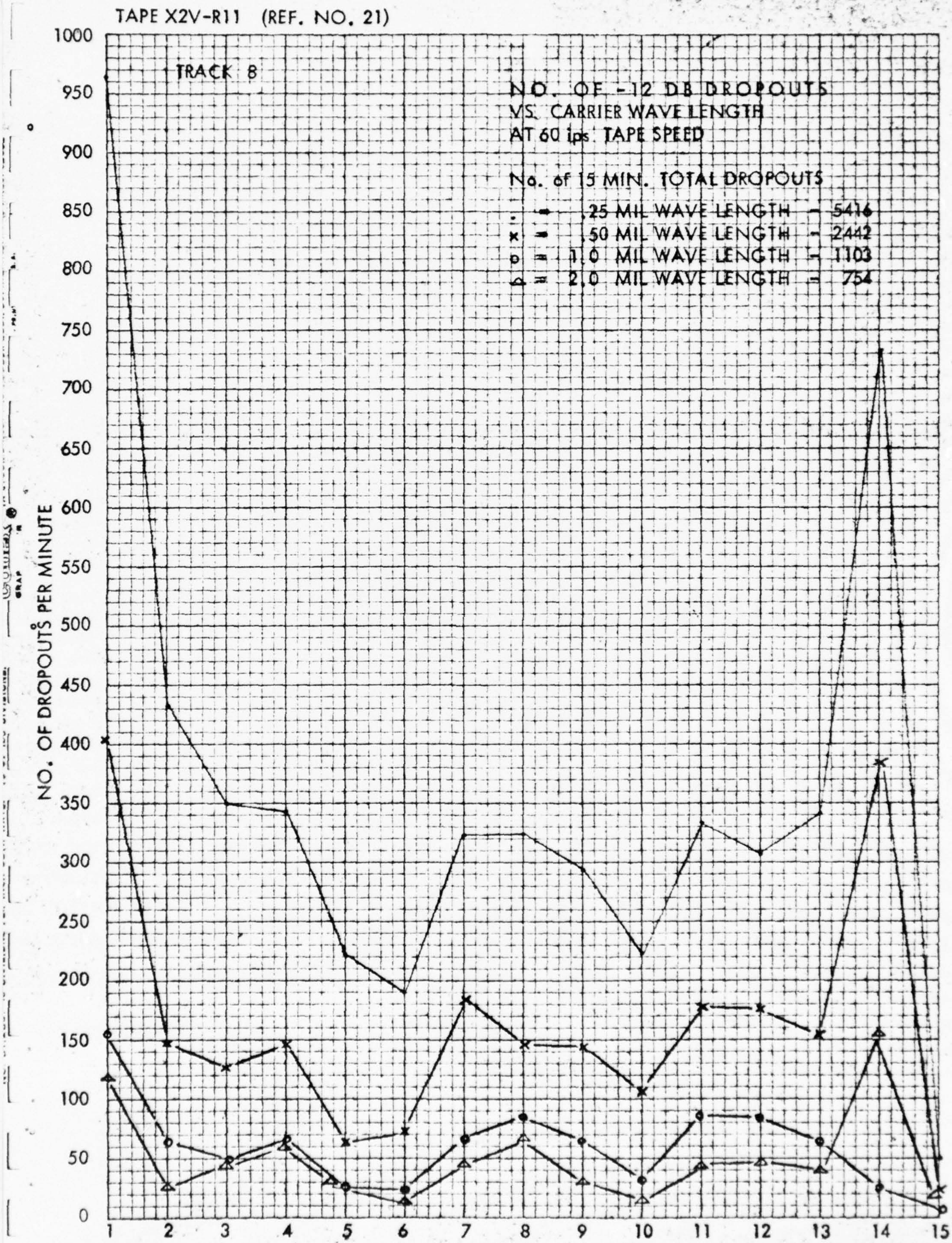
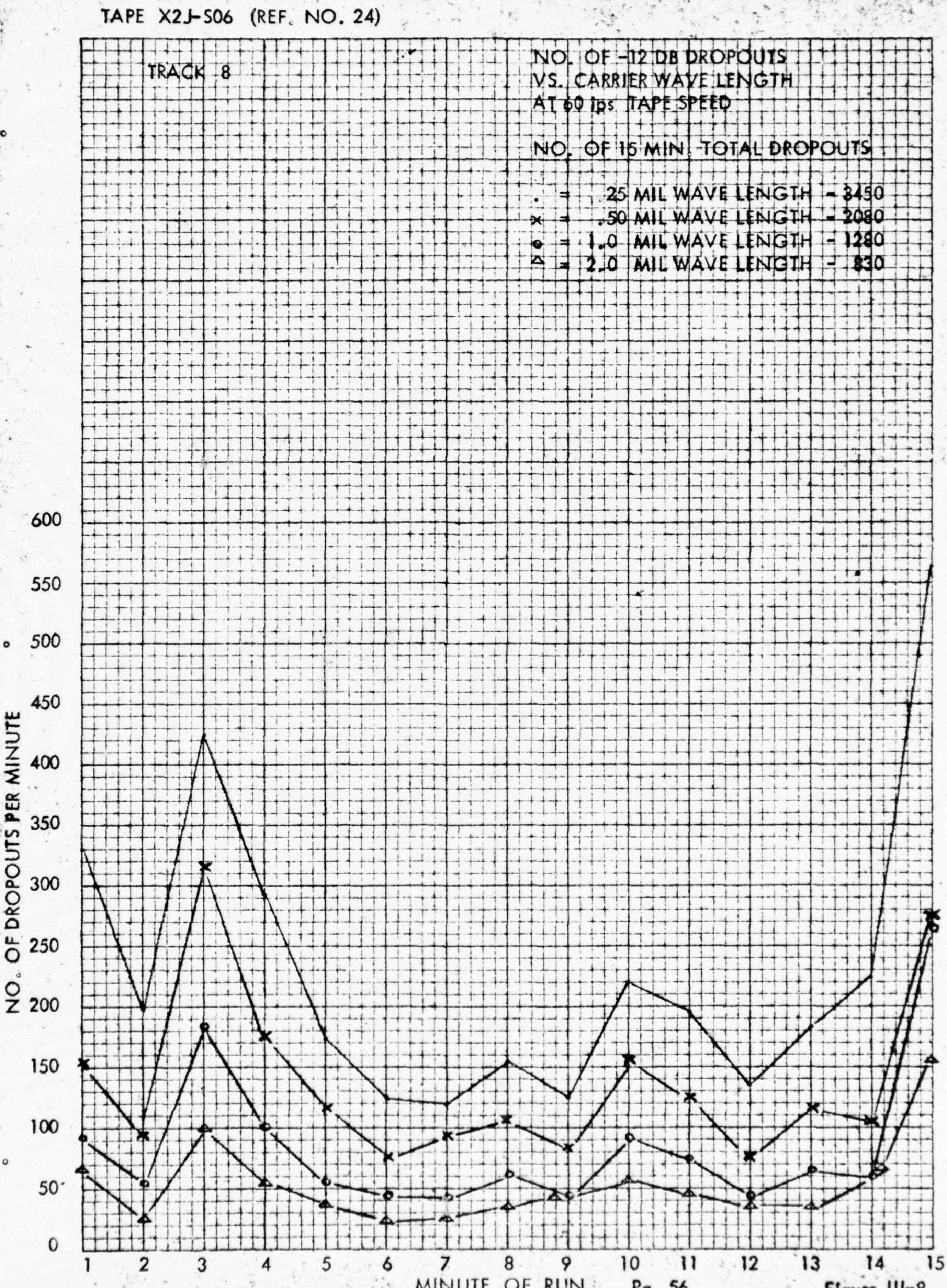


Figure III-6



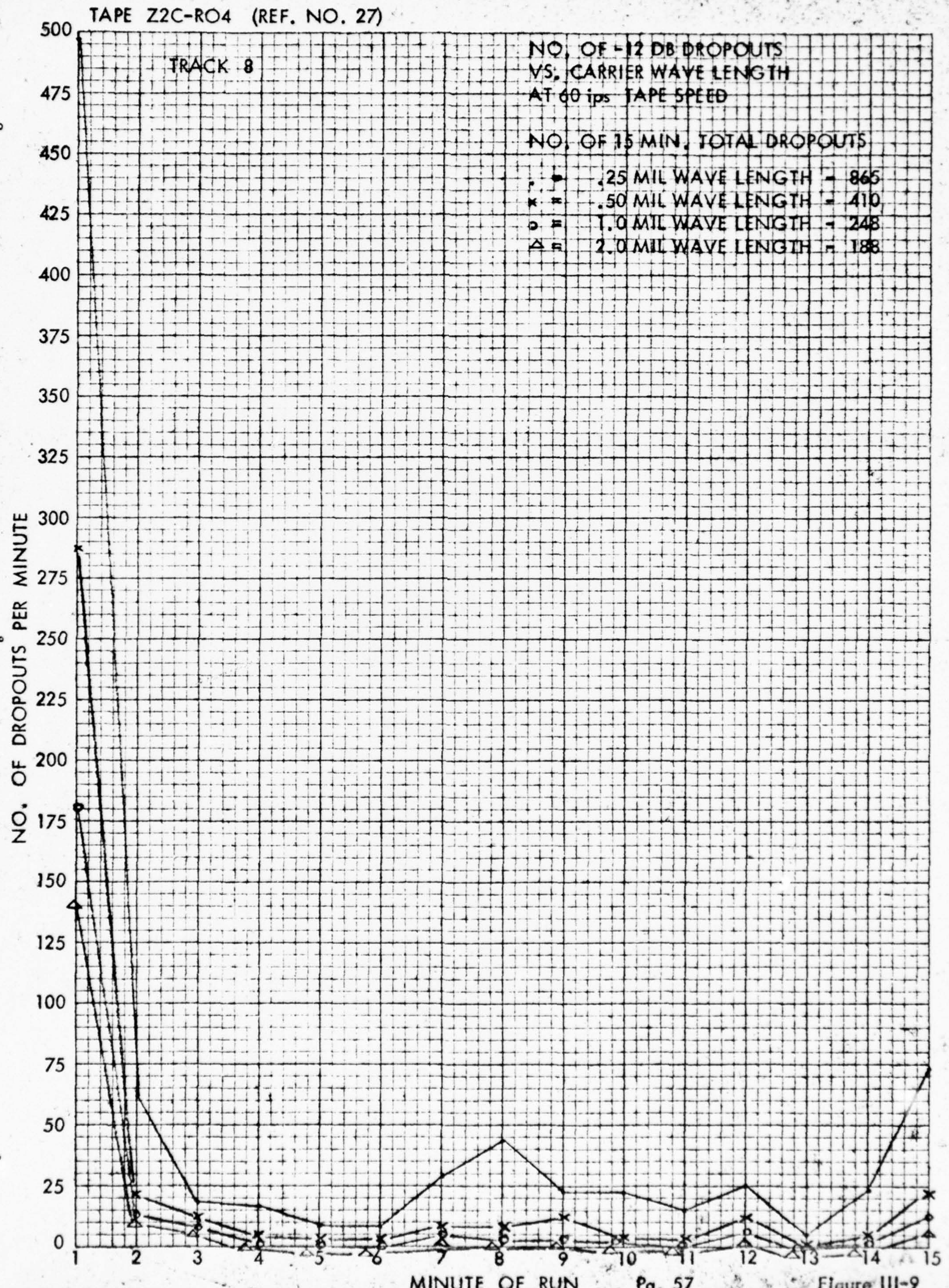
TAPE X2V-R11 (REF. NO. 21)
TRACK 8
NO. OF -12 DB DROPOUTS
VS. CARRIER WAVE LENGTH
AT 60 ips TAPE SPEED
No. of 15 MIN. TOTAL DROPOUTS
• = .25 MIL WAVE LENGTH - 5416
x = .50 MIL WAVE LENGTH - 2442
o = 1.0 MIL WAVE LENGTH - 1103
△ = 2.0 MIL WAVE LENGTH - 754
NO. OF DROPOUTS PER MINUTE
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
MINUTE OF RUN

Figure III-7



Pg. 56

Figure III-8



TAPE Z2C-RO4 (REF. NO. 27)
TRACK 8
NO. OF -12 DB DROPOUTS
VS. CARRIER WAVE LENGTH
AT 60 ips TAPE SPEED
NO. OF 15 MIN. TOTAL DROPOUTS
.25 MIL WAVE LENGTH - 865
.50 MIL WAVE LENGTH - 410
1.0 MIL WAVE LENGTH - 248
2.0 MIL WAVE LENGTH - 188
NO. OF DROPOUTS PER MINUTE
500
475
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
MINUTE OF RUN

Figure III-9

TAPE Y3S-A55 (REF. NO. 30)

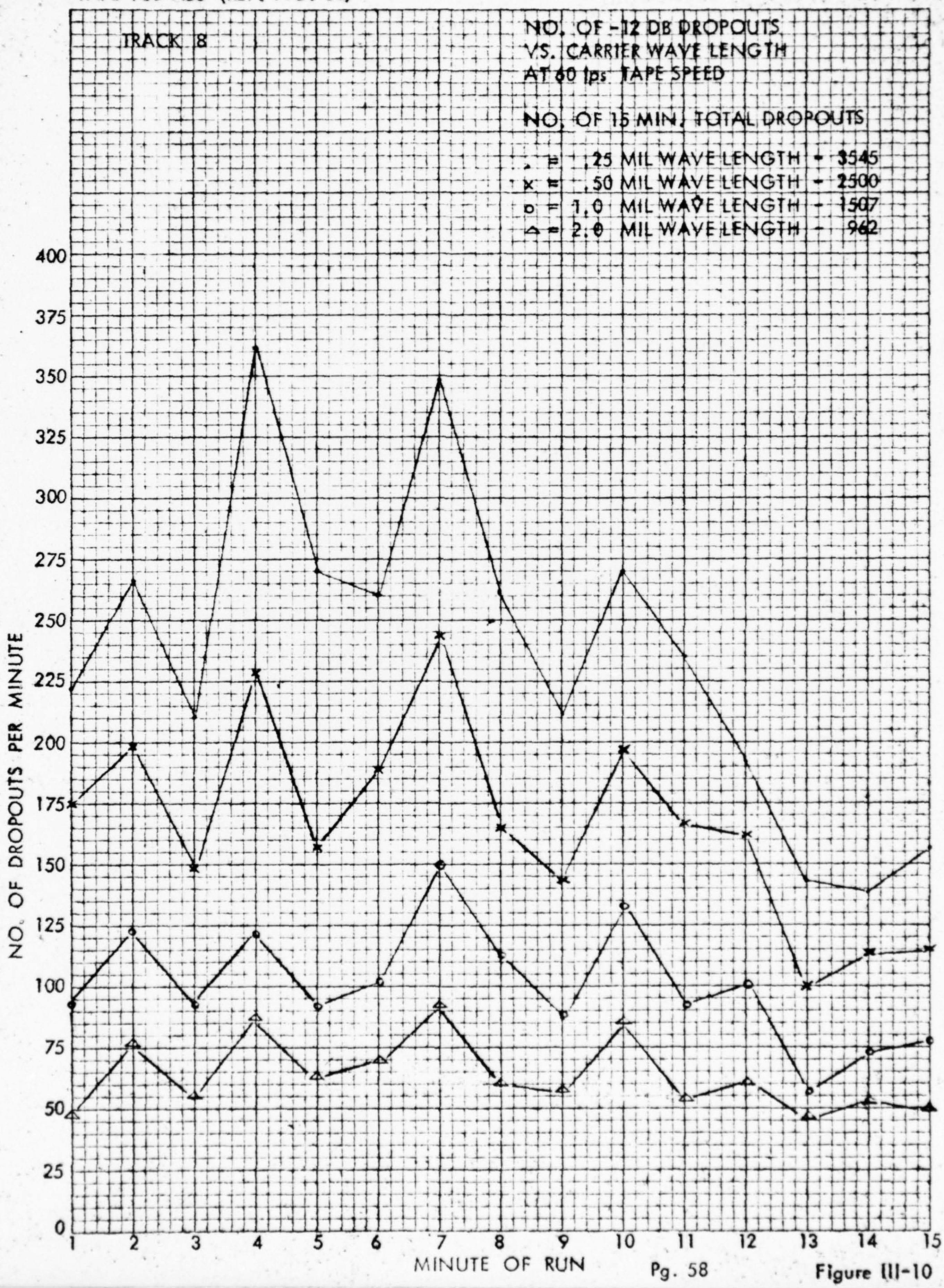


Figure III-10

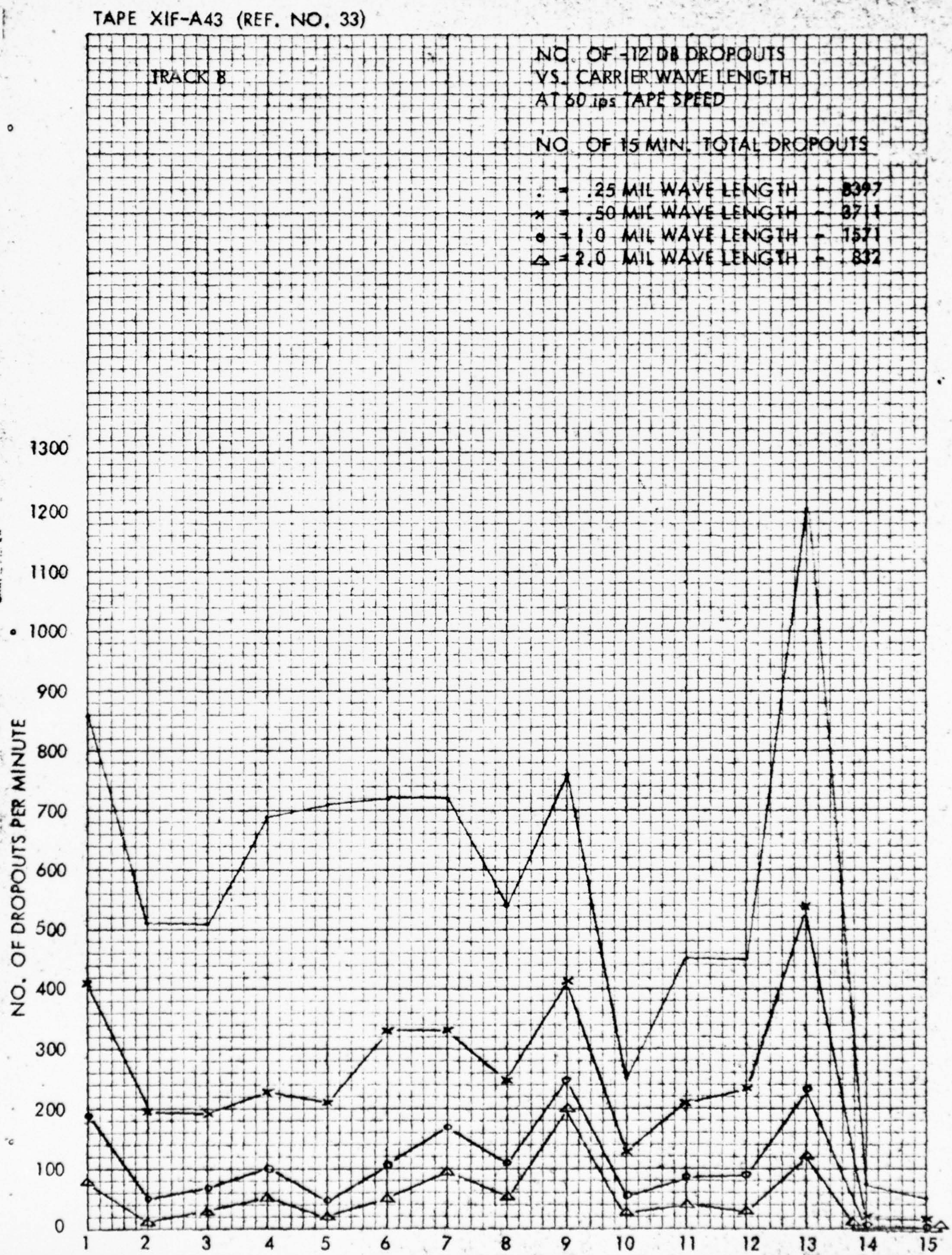


Figure III-11

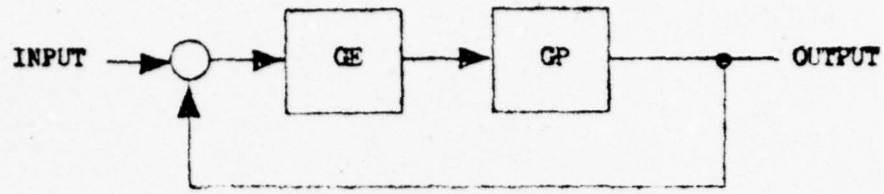


FIGURE IV-1. UNITY FEEDBACK SYSTEM

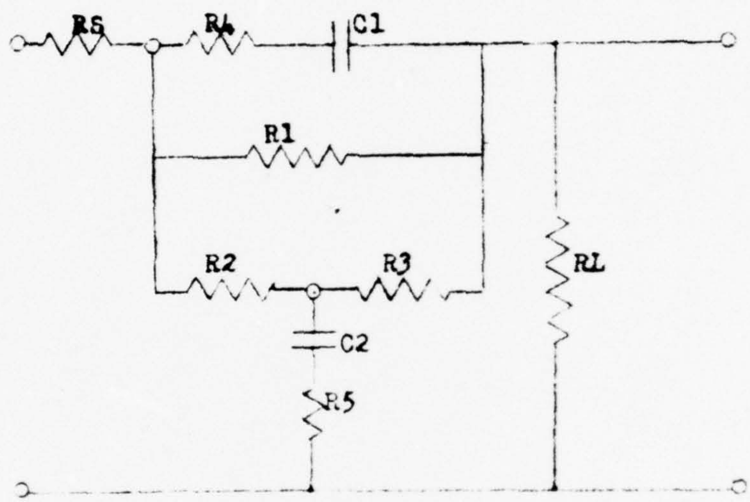


FIGURE IV-2 REPRODUCE STABILIZATION NETWORK

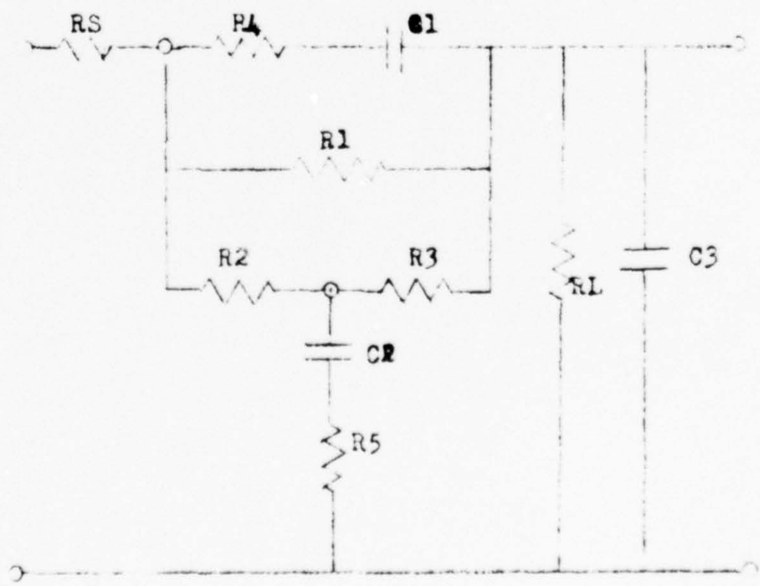


FIGURE IV-3A RECORD STABILIZATION NETWORK

FIGURE IV-4

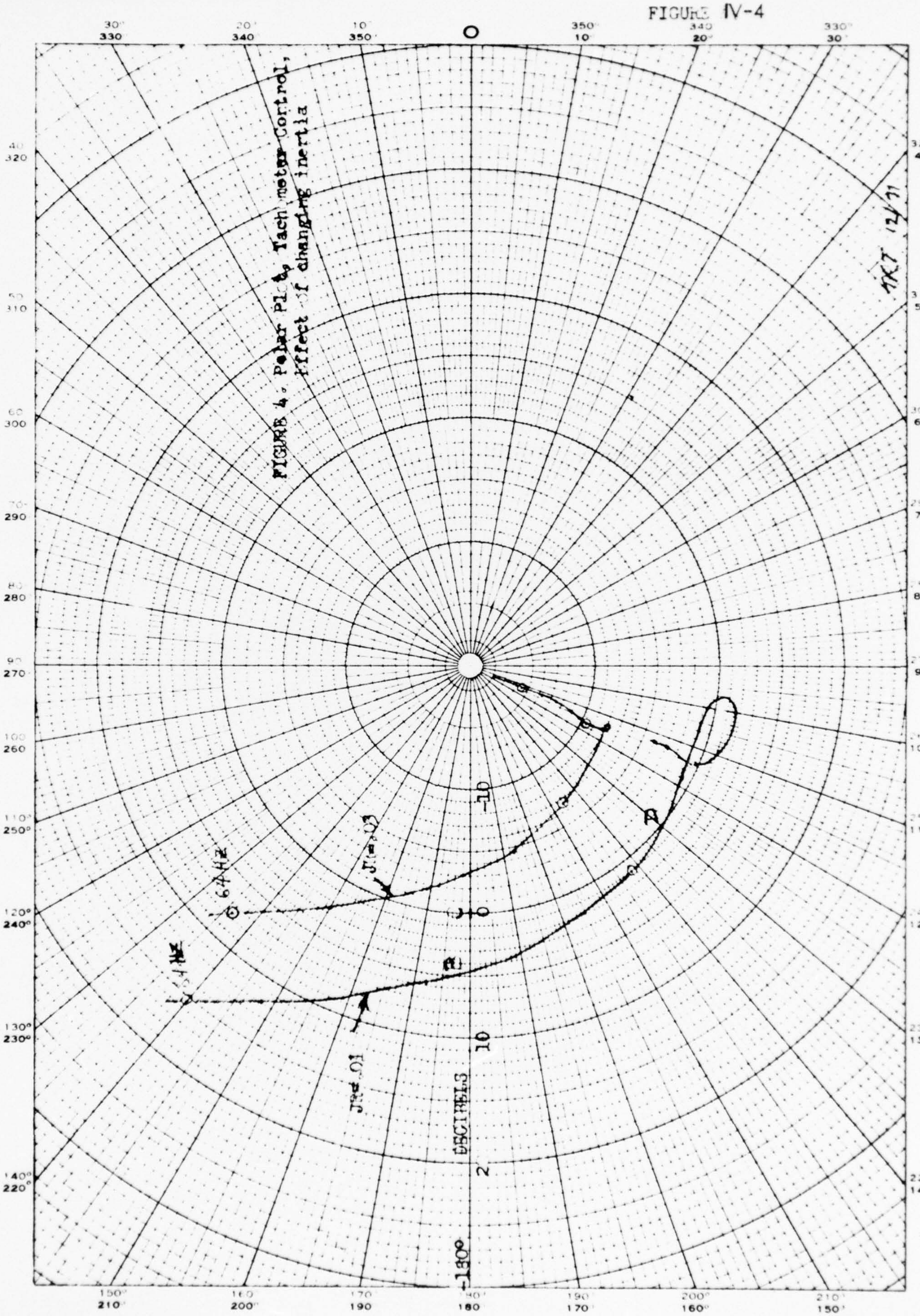


FIGURE 4. Polar Plot, Tachometer Control, Effect of changing inertia
TKT 12/71
64 Hz
64 Hz
JT=.03
JT=.01
DECIBELS
-10
0
10
20
-180°

FIGURE IV-5

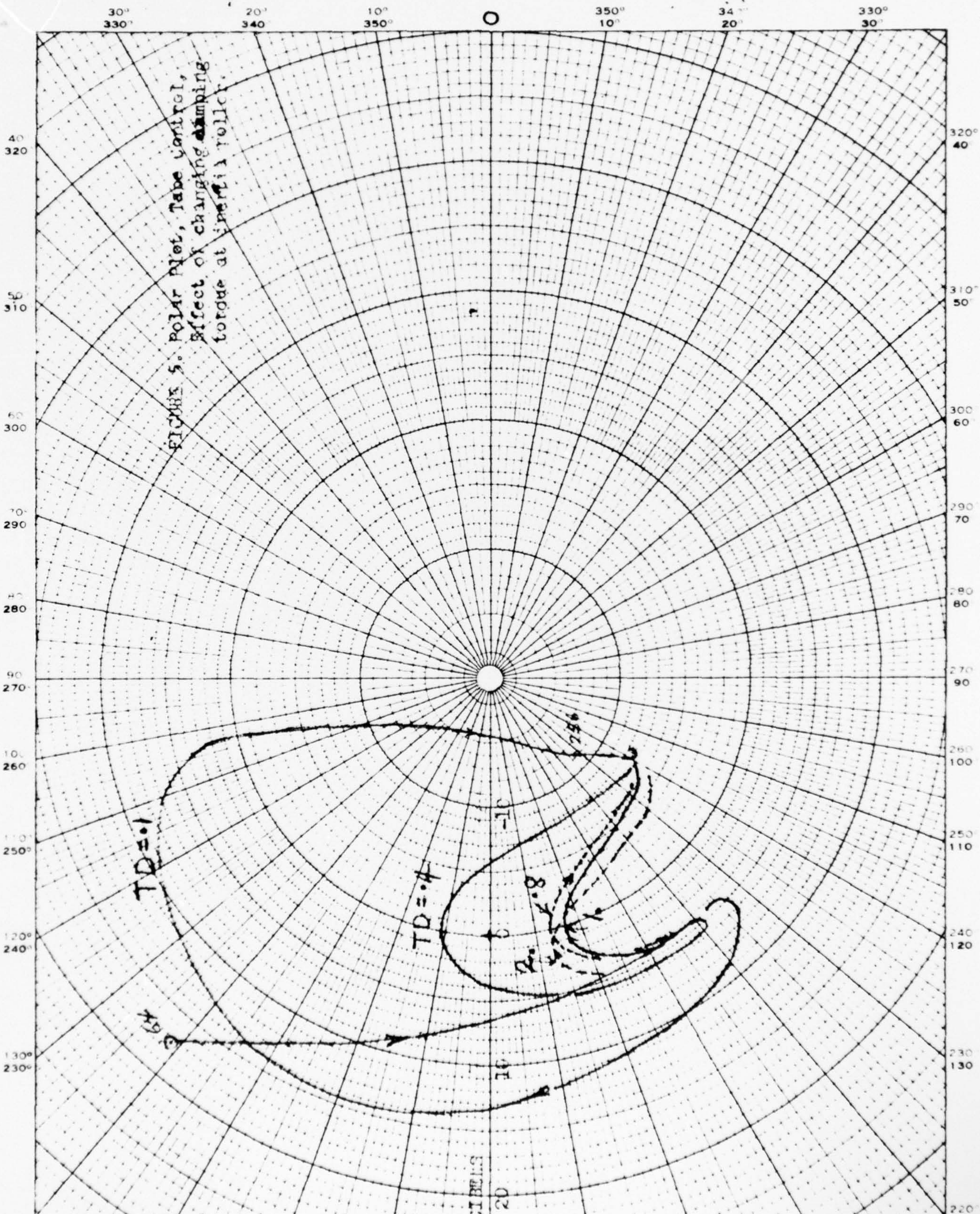


FIGURE 5. Polar Plot, Tabe control, Effect of changing damping torque at inertial roller
TD=.1
TD=.4
TD=.8
TD=2.
-180° DECIBELS
POLAR CO-ORDINATE PAPER
MADE IN U. S. A.

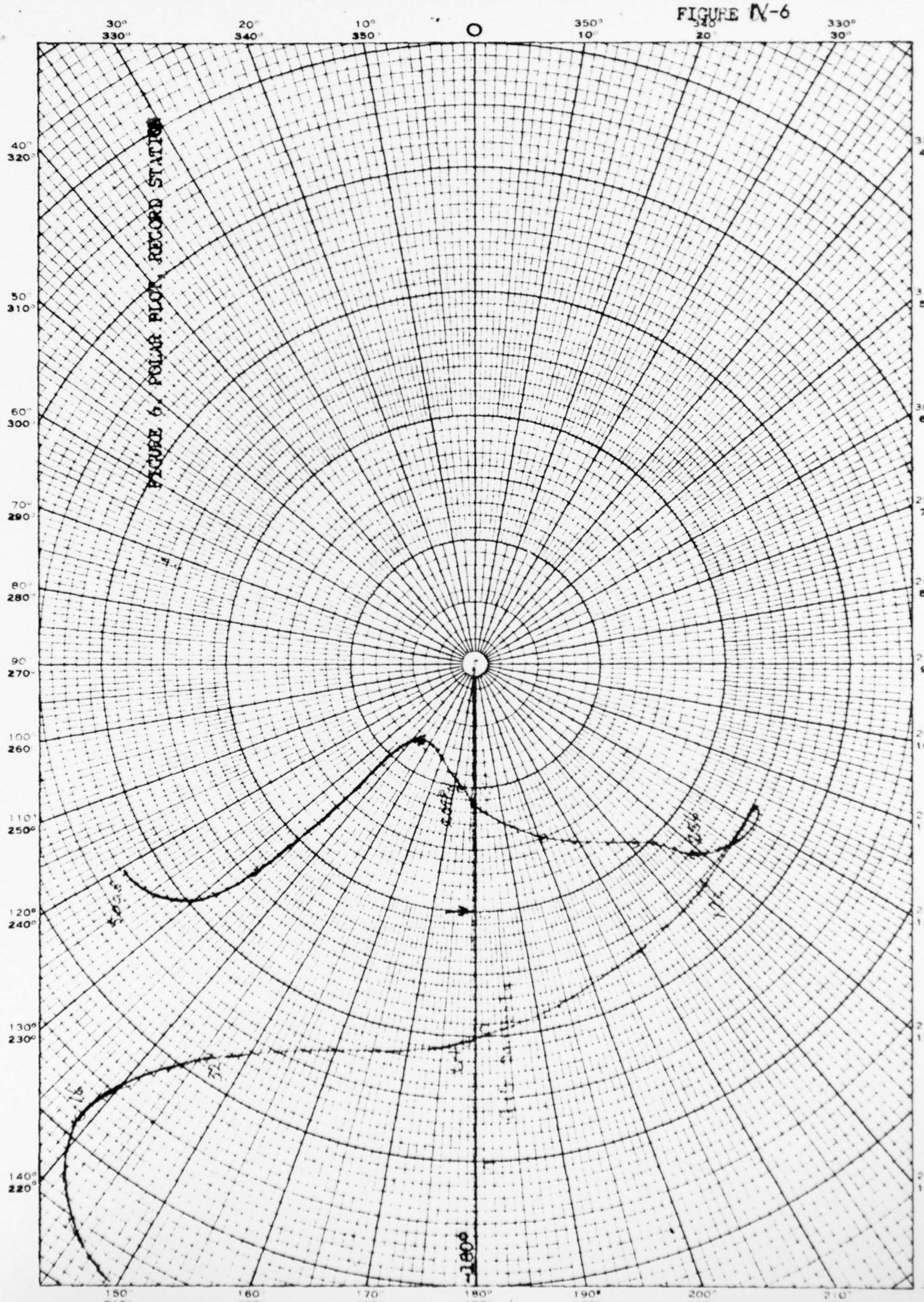


FIGURE 6, POLAR PLOT, RECORD STATION
0
180

FIGURE IV-7

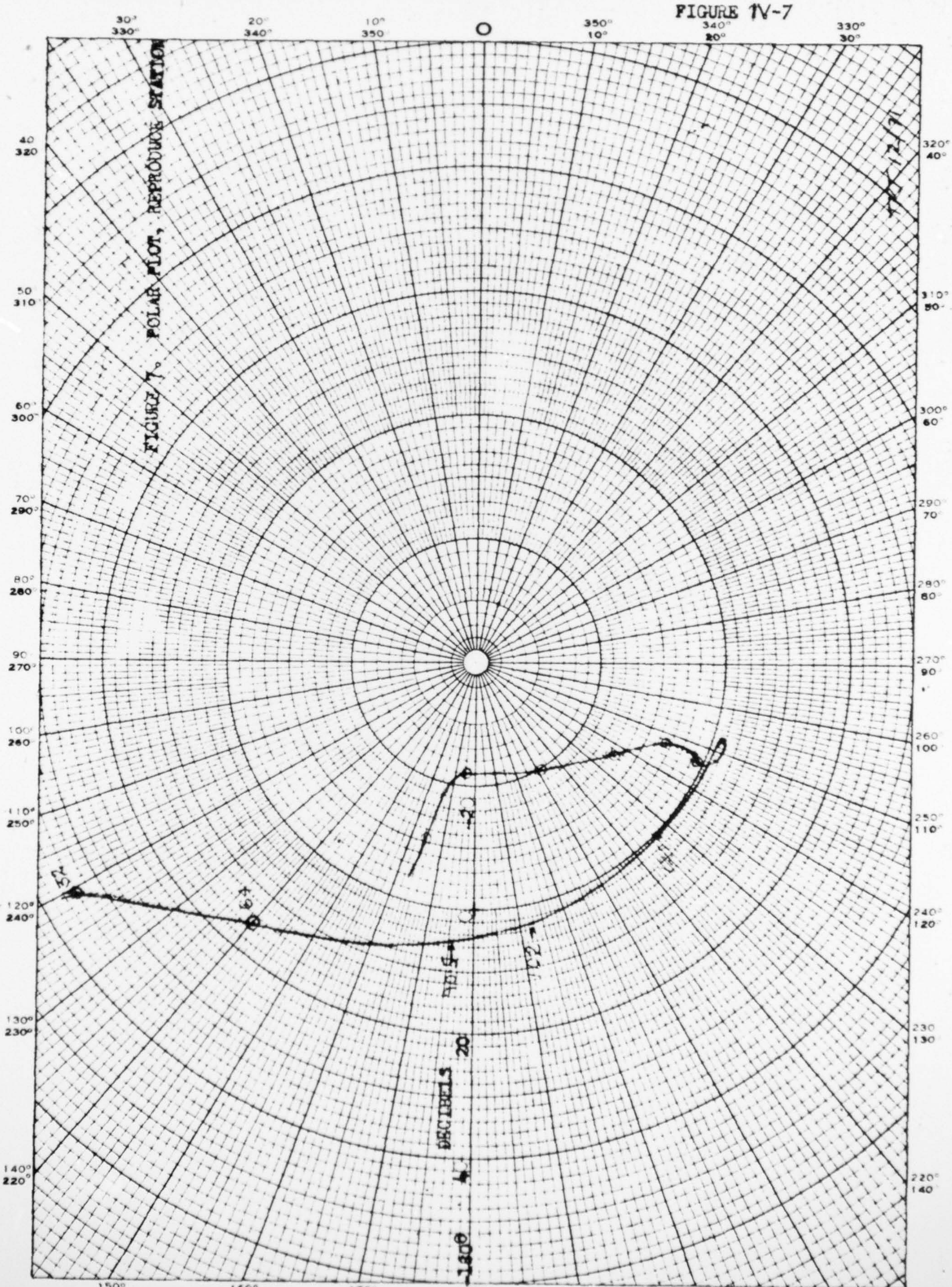


FIGURE 7. POLAR PLOT, REPRODUCE STATION
DECIBELS
20
-130
O
32
64

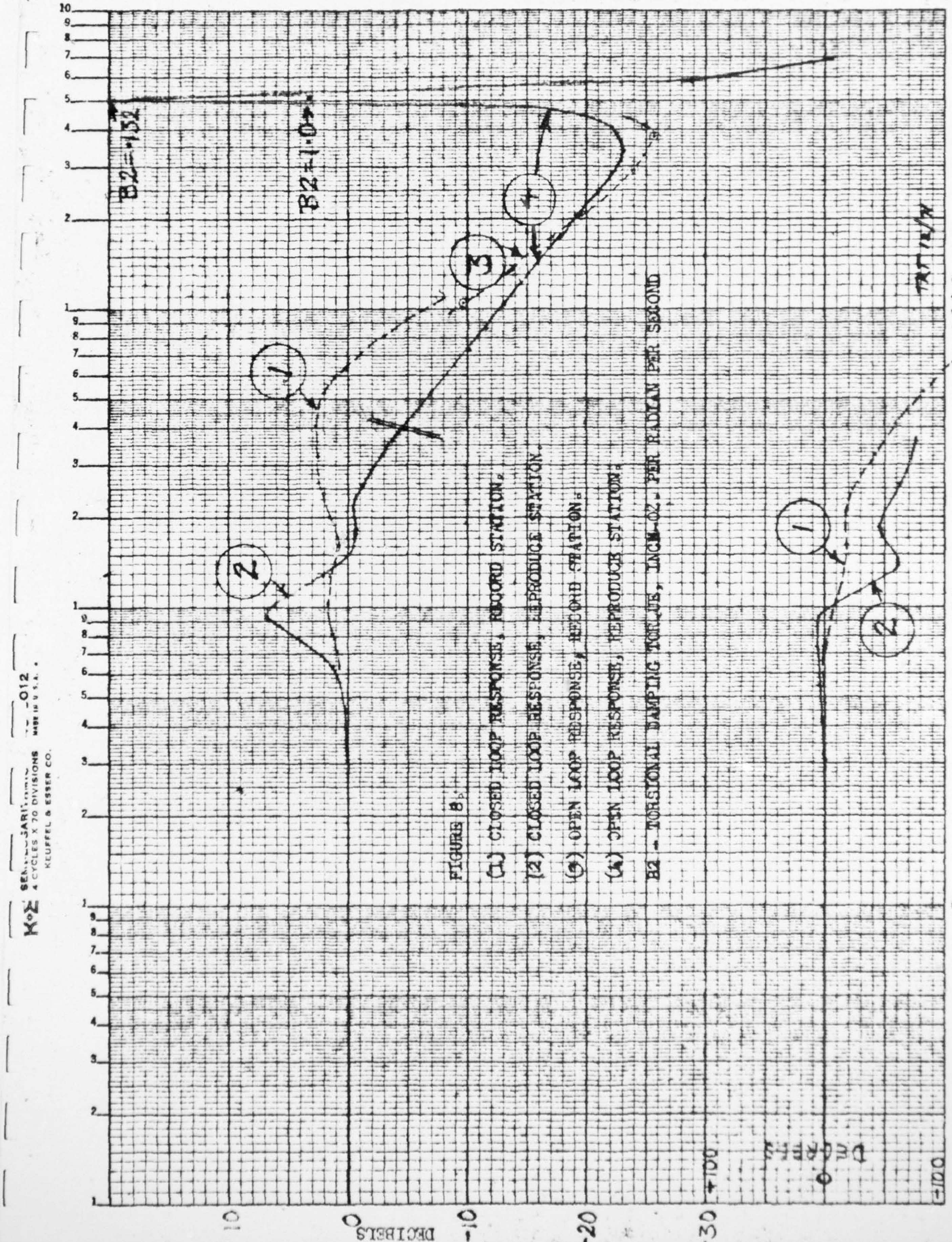


FIGURE 8b
(1) CLOSED LOOP RESPONSE, RECORD STATION.
(2) CLOSED LOOP RESPONSE, REPRODUCE STATION.
(3) OPEN LOOP RESPONSE, RECORD STATION.
(4) OPEN LOOP RESPONSE, REPRODUCE STATION.
B2 - TORSIONAL DAMPING TORQUE, INCH-OZ. PER RADIAN PER SECOND
B2=.132
B2=1.0
DECIBELS
10
0
-10
-20
-30
DEGREES
+100
0
-100
HERTZ
10
100
1000

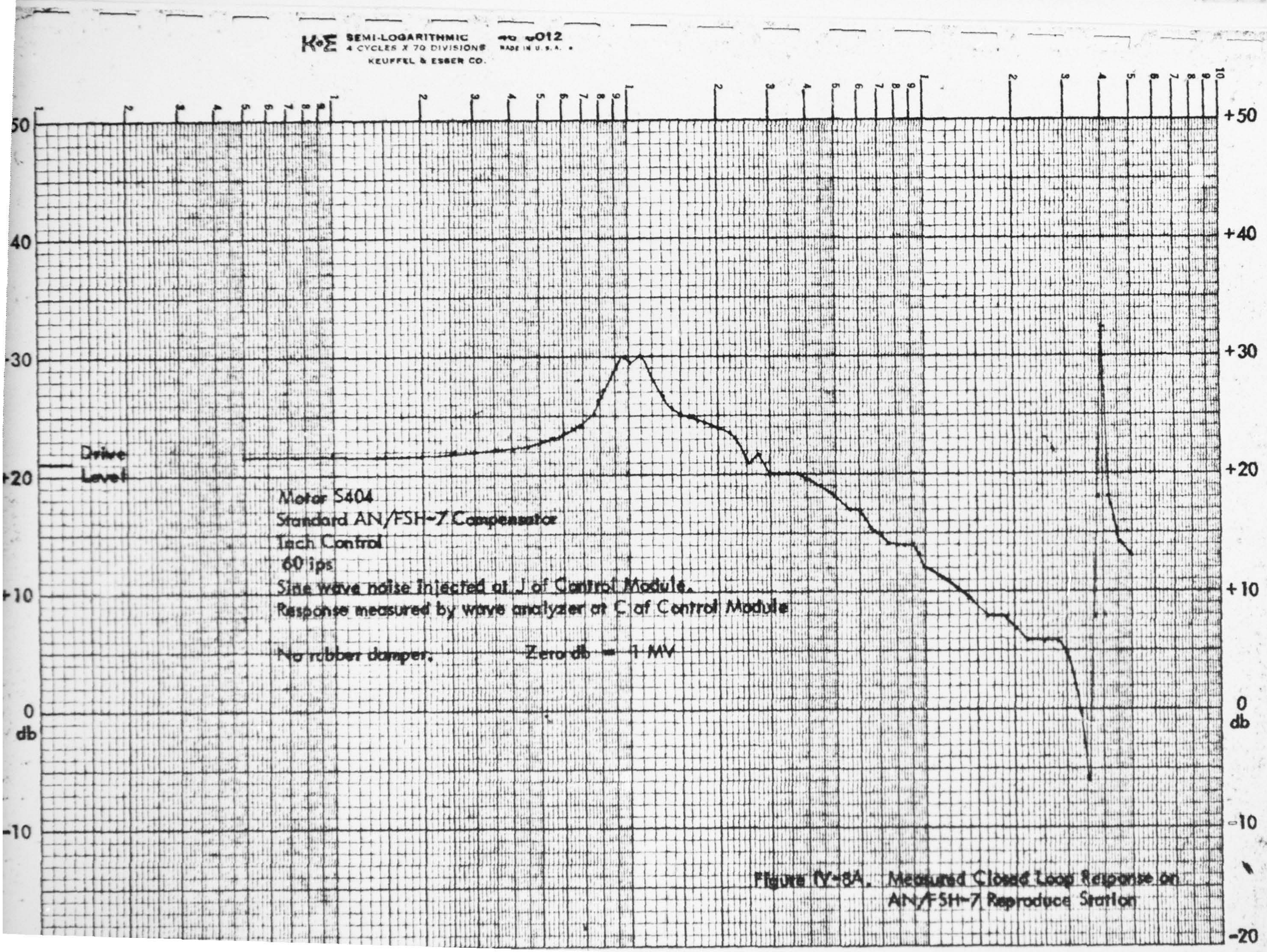
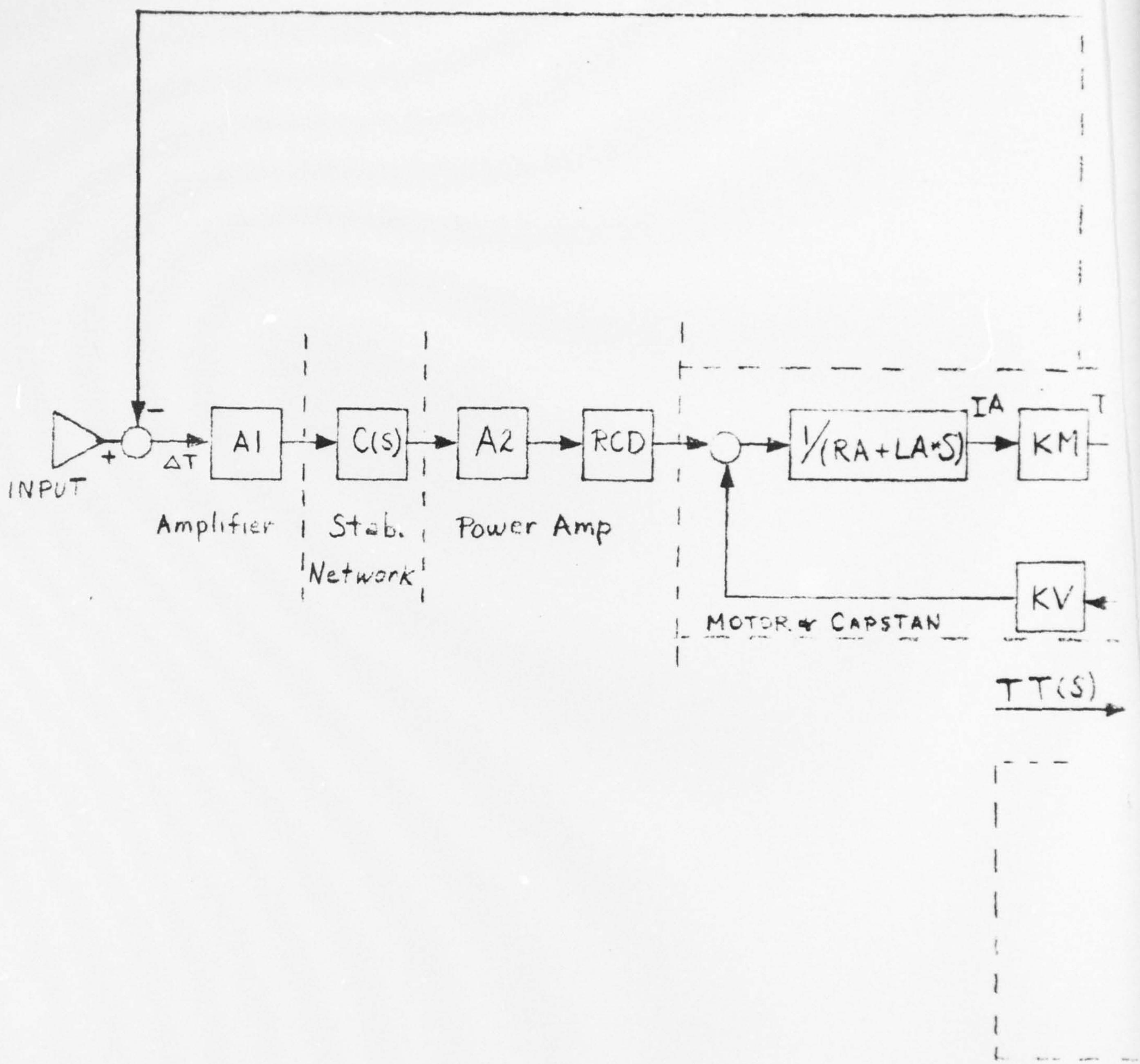


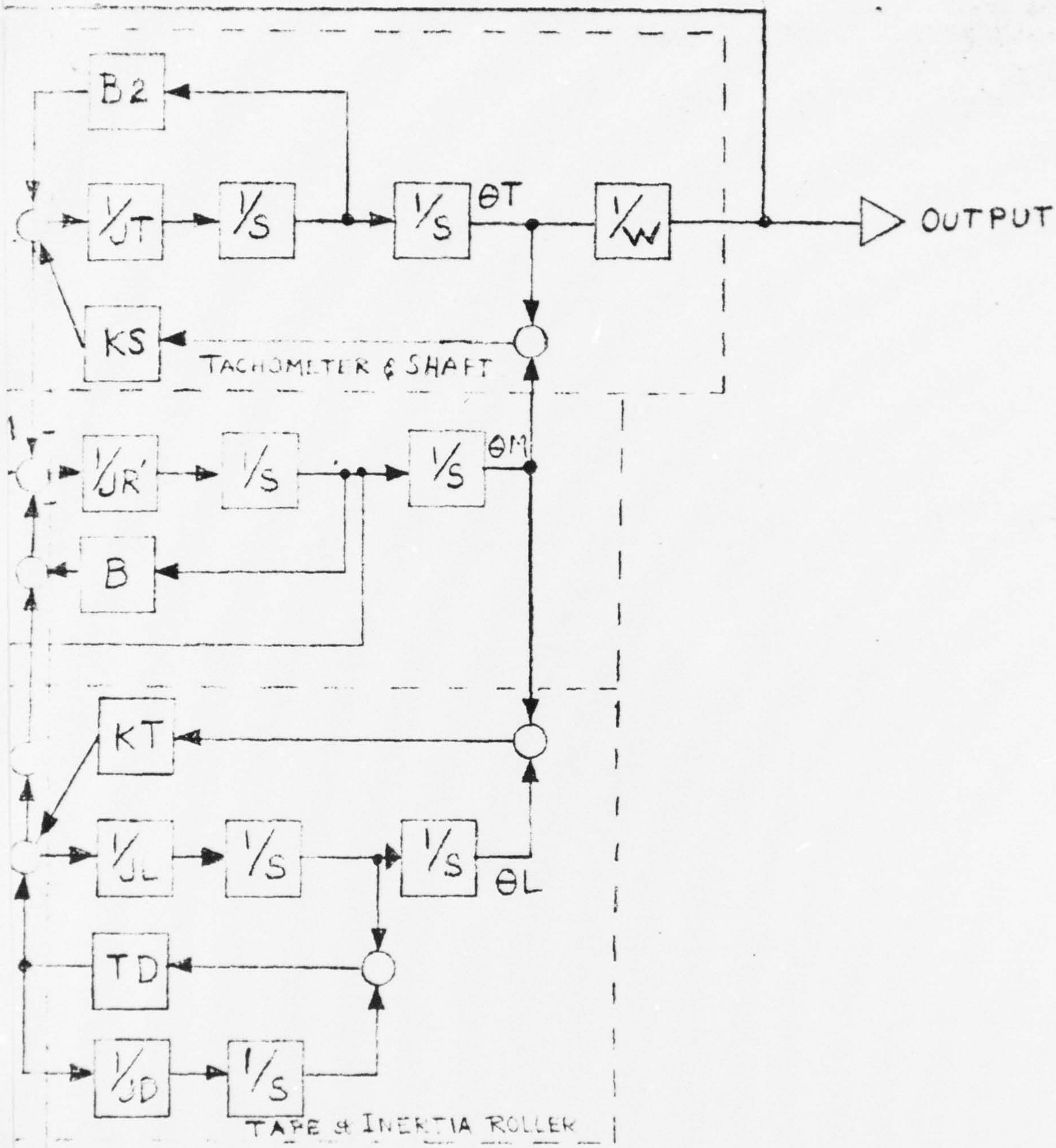
Figure IV-8A. Measured Closed Loop Response on AN/FSH-7 Reproduce Station



REVISIONS

K+F 10 5156

DRAWING NUMBER	REV.



PART TO BE FREE OF BURRS AND SHARP EDGES

SCALE:		MATERIAL:	
DRAWN TKT	DATE DEC '71		
CHECKED	DATE	FINISH:	HEAT TREAT
DIM. TOLERANCES FRACT. ± 1/64 DECIMAL ± .005 ANGULAR ± 1/2° UNLESS OTHERWISE SPECIFIED		TAPE RECORDER SERVO TACHOMETER CONTROL	
KENTON ENGINEERING CORP. SKOKIE, ILLINOIS		DRAWING NUMBER FIG. IV-9	REV.

APPENDIX A

Program TF118A

This is a program to generate the transfer function of the tape recorder servo in tape control. It is based on the model described in the first quarterly report. These are 20 parameters which may be varied during operation (see Appendix C). The output is the amplitude and phase of the system as a function of frequency. Referring to Figure IV-1, which is a schematic of a unity return feed-back circuit, the program computes the transfer function of block GP. This is the forward gain of the system, exclusive of the stabilization network GE. The servo is a position servo, hence the output is the ratio of the output shaft position to the input reference demand.

Motion sensing (output) in Program TF118A is done at the magnetic head. Its position is determined by the variable A, the distance along the tape from capstan to the head gap. A related variable LTT is the transport delay, the actual time delay in terms of wave propogation from the capstan to the head.

Program TF118T

This program is the same as TF118A except that output data is stored in computer files FREQ A, for frequencies and TOLST for the complex transfer function values. This program is listed in Appendix B.

Program TF1119A and TFDAMP

These programs generate the transfer function of the tape recorder under tachometer speed control. In this mode motion sensing is derived from the tachometer disc. The model simulates torsional vibrations in the motor shaft, as shown in Fig. IV-9. TFDAMP includes damping for this vibration. It also stores output data in FREQ A and TOLST files.

Program C1R2 and C1R2T

These compute the transfer function of equalizers (of the same configuration) as those used at the reproduce station on the original FSH-7. Data from C1R2T is stored in computer files FREQ B and CR1T2. The circuit is shown in Figure IV-2.

Program C1R2B

This program computes the transfer function of the original equalizer used at the record capstan of the FSH-7. Computer data files written are FREQ B and CR1T2. The circuit is shown in Figure IV-3.

Program AB

This program computes:

(1) GE * GP or (2) GE * GP/(1+GE * GP); the open loop and unity feedback gains shown in Figure 1.

Here GE = CRIT2, and GP = TOLST. Data inputs FREQ A and FREQ B are also used.

Program ABD

This program computes the open loop gain and the effect of a disturbing force on the system.

Computer Operation

Example: To compute the closed loop transfer function of the system under tachometer control at the record capstan.

After signing on the time-share system the following procedure occurs.

1. Computer: SYSTEM
2. User: FOR, OLD, TFDAMP
3. Computer: READY
4. User: RUN
5. Computer: ENTER NUMBER OF CHANGES?
6. Referring to the parameter list, the user will decide how many changes he wishes to make.

   User: 2
7. Computer: PARAMETER NUMBER?
8. User: 3 (for JR)
9. Computer: VALUE
10. User: .015

11. Computer: PARAMETER NUMBER?

12. User: 20 (for starting frequency value)

13. Computer: VALUE?

14. User: 64 (for 64 Hertz)

15. Computer: CALCULATIONS PER OCTAVE?

16. User: 6

17. The computer will now list the parameter values; unless the frequency only is changed.

18. The computer will compute and list:
FREQUENCY, HERTZ; AMPLITUDE, DB: PHASE, DEGREES

19. Computer: ENTER NUMBER OF CHANGES?

20. If the user is satisfied with the configuration he terminates the run.

User: STOP

21. Output data is in computer files FREQ A and TOLST.

22. User: FOR, OLD, CIR2B

23. Computer: READY

24. User: RUN

25. Proceed as in Steps 5 thru 20; output data is now in computer files FREQ B and CR1T2.

26. User: FOR, OLD, AB

27. Computer: READY

28. User: RUN

29. Computer: ENTER 1 FOR OPEN LOOP,
ENTER 2 FOR UNITY FEEDBACK?

30. User: 2

31. Computer lists, frequency, amplitude and phase for the closed loop gain.

32. Error Condition: The frequency values in Program TFDAMP and CIR2B must be identical.

```
. LIST

 12/24/71. 18.49.53.
PROGRAM    TF1187

      PRØGRAM TF1187 (INPUT,ØUTPUT,TAPE1,TAPE3,PFUR)
      ØPEN LØØP TRANSFER FUNCTIØN FØR ANALØG TAPE RECØRDER
      PRØGRAMMER T. R. THØMAS
      REAL JD,JL,JR,KM,KT,KV,LTT
      REAL LA
          COMPLEX S,T1,T2,T3,T4,T5,T6,T7,T8,T9,T10,T11,T12,
      T13,T14,T15,T16,T17,TAU,T18,T19,T20,T21,T22,TØL,TCL
      ,T23
      DIMENSIØN AR(40),AT(16),CT(32)
      REAL AR
        EQUIVALENCE (AR(1),JD),(AR(2),JL),(AR(3),JR),(AR(4),KM),
      (AR(5),KT),(AR(6),KV),(AR(7),LTT),(AR(8),TD),(AR(9),RC),
      (AR(10),RD),(AR(11),A),(AR(12),D),(AR(13),A1),
      (AR(14),A2),(AR(15),RCD),(AR(16),RA),(AR(17),LA)
      ,(AR(18),B),(AR(19),W),(AR(20),FREQ1)
         DATA JD/.00149/,JL/.00128/,JR/.01/,KM/8.3/,KT/1390./,
      KV/.05/,LTT/.000033/,TD/.378/,RC/.498/,RD/.6/,A/1.0/,
      D/3.0/,A1/2.E6/,A2/3.3/,RCD/100./,RA/1.7/,LA/.0035
      /,B/.264/,W/120./,FREQ1/1./
      DØ 90 KRUN=1,10
      FREQ1=1.
      PRINT,*SPECIFY THE NUMBER ØF PARAMETERS TØ BE CHANGED. LL=*,
           READ ,LL
          IF(LL.EQ.0)GØTØ 6
          DØ 5 I=1,LL
      PRINT,*ENTER LIST SUBSCRIPT FRØM EQUIVALENCE STATEMENT*,
          READ, LLL
      PRINT,*ENTER NEW VALUE ØF PARAMETER*,
      READ,AR(LLL)
    5    CONTINUE
     6PRINT,*SPECIFY CALCULATIØNS PER ØCTAVE, N=*,
      READ,N
         FACT=EXP(ALØG(2.0)/N)
      THIS CALCULATIØN MAY BE CYCLED UP TØ TEN TIMES BEFØRE
      TERMINATING
      IF(LLL.EQ.20.AND.LL.EQ.1)GØTØ 100
      PRINT,*              JD,                JL,              JR,*
         PRINT 99, JD,JL,JR
   99FØRMAT(3E14.4)
      PRINT,*              KM,                KT,              KV,*
         PRINT99,KM,KT,KV
         PRINT,*             LTT,              TD,              RC,*
         PRINT 99,LTT,TD,RC
         PRINT,*               RD,               A,               D,*
         PRINT 99,RD,A,D
        PRINT ,*               A1,              A2,             RCD,*
         PRINT 99,A1,A2,RCD
      PRINT,*              RA,                LA,               B,*
      PRINT 99,RA,LA,B
      PRINT,*              W,*
```

```
      PRINT99,W
  100PRINT,* FREQUENCY,HZ, AMPLITUDE,DB,      PHASE,DEG.*
      IRUN=0
      RRA=RA+RCD
   26FREQ=FREQ1
        DØ 30 I=1,N
        ØMEGA=FREQ*6.28318
        S=CMPLX(0.0,ØMEGA)
      T1=(1./JR)*(1./S)
        T2=T1/(1.+T1*B)
        T3=(1./JD)*1./S
      T4=TD/(1.+T3*TD)
      T5=(1./JL)*(1./S)
      T6=T5/(1.+T5*T4)
      T7=T6/S
      T8=T7
      T9=KT/(1.+KT*T8)
      T10=T9*T8
      T11=(1.-A/D)+T10*A/D
      T12=1./S
      T13=T12*T11
      T14=T12*T9
      T15=T2/(1.+T2*T14)
      TAU=CEXP(-LTT*S)
      T16=TAU*1./W
      T17=T13*T16
      T18=A1
      T19=A2*RCD
      T20=KM/(RRA+LA*S)
      T21=T20*T15
      T22=T21/(1.+T21*KV)
      T23=T19*T22
      TØL=A1*1.*T23*T17
      TCL=TØL/(1.+TØL)
      AMP=CABS(TØL)
      AMP=20.*ALØG10(AMP)
      PHASE=57.29578*ATAN2(AIMAG(TØL),REAL(TØL))
      IF(PHASE.GT.0)PHASE=PHASE-360.
      IRUN=IRUN+1
      IF(IRUN.GT.16)GØTØ 80
      PRINT 98,FREQ,AMP,PHASE
   98FØRMAT(3F13.3)
      TØL1=REAL(TØL)
      TØL2=AIMAG(TØL)
      K=2*IRUN-1
      CT(K)=TØL1
      L=K+1
      CT(L)=TØL2
      AT(IRUN)=FREQ
   30 FREQ=FREQ*FACT
      FREQ1=FREQ1*2.
      GØTØ26
   80WRITE(1,)AT
      REWIND 1
      WRITE(3,)CT
      REWIND 3
      CALL PFUR(3HREP,5HTAPE1,5HFREQA,0,ISTA)
      CALL PFUR(3HREP,5HTAPE3,5HTØLST,0,ISTA)
   90CØNTINUE
```

```
LIST,00680

 12/24/71. 18.11.43.
PRØGRAM    TFDAMP

           IRUN=0
           RRA=RA+RCD
         26FREQ=FREQ1
              DØ 30 I=1,N
              ØMEGA=FREQ*6.28318
              S=CMPLX(0.0,ØMEGA)
           T1=(1./JR)*(1./S)
              T2=T1/(1.+T1*B)
              T3=(1./JD)*1./S
           T4=TD/(1.+T3*TD)
           T5=(1./JL)*(1./S)
           T6=T5/(1.+T5*T4)
           T7=T6/S
           T8=T7
           T9=KT/(1.+KT*T8)
           T10=T9*T8
           T11=(1.-A/D)+T10*A/D
           T24=(1./S)*(1./(JT*S+R2))
           T25=KS/(1.+KS*T24)
           T26=T25*T24
           T29=T9+T25
           T30=T26/S
           T31=T29/S
           T32=T2/(1.+T2*T31)
           T16=1./W
           T17=T16*T30
           T18=A1
           T19=A2*RCD
           T20=KM/(RRA+LA*S)
           T21=T32*KV
           T22=T20/(1.+T20*T21)
           T23=T19*T22
           TD1=T23*T18
           TØL=TD1*T32*T17
           AMP=CABS(TØL)
           AMP=20.*ALØG10(AMP)
           PHASE=57.29578*ATAN2(AIMAG(TØL),REAL(TØL))
           IF(PHASE.GT.0)PHASE=PHASE-360.
           IRUN=IRUN+1
           IF(IRUN.GT.16)GØTØ 80
           PRINT 98,FREQ,AMP,PHASE
      98   FØRMAT(3F13.3)
           TØL1=REAL(TØL)
           TØL2=AIMAG(TØL)
           K=2*IRUN-1
           L=K+1
           CT(K)=TØL1
           CT(L)=TØL2
           EØ=REAL(TD1)
           EE=AIMAG(TD1)
           ET(K)=EØ
           ET(L)=EE
           AT(IRUN)=FREQ
      80   FREQ=FREQ*FACT
           FREQ1=FREQ1*2.
```

APPENDIX C

Parameter List

	Symbol	Nominal Value	Remarks
1.	JD	.00149 oz-in-sec^2	Moment of inertia of internal roller in inertia damper.
2.	JL	.00128 oz-in-sec^2	Moment of inertia of external roller inertia damper.
3.	JR	.01 oz-in-sec^2	Moment of inertia of motor armature, capstan and pinch-rollers.
4.	KM	8.3 oz-in/amp.	Motor torque output.
5.	KT	1890 oz-in/radian	Elastic restoring torque thru tape between the capstan and inertia roller.
6.	KV	.05 volts/rad/sec	Back emf capstan motor.
7.	LTT	33 microseconds	Transport delay through the tape from capstan to pickup head.
8.	TD	.1 oz-in/rad/sec	Damping torque of inertia roller.
9.	RC	.498 in.	Capstan radius.
10.	RD	.6 in.	Inertia roller radius.
11.	A	1. in.	Distance from capstan to pickup head.
12.	D	3. in.	Distance from capstan to inertia roller along the tape path.
13.	A1	2.*10^6 volts/sec	Pre-amplifier gain due to time base error.
14.	A2	3.3 amps/volt	Power amplifier conversion factor.
15.	RCD	100 ohms	Power amplifier impedance.
16.	RA	1.7 ohms	Capstan motor impedance resistive.
17.	LA	.0035 henries	Capstan motor impedance inductive.

Parameter List (Cont'd)

	Symbol	Nominal Value	Remarks
18.	B	.264 oz-in/rad/sec	Damping torque of capstan motor.
19.	W	120. rad/sec	Angular speed of capstan, 60 ips.
20.	FREQ 1	1. Hertz	Starting frequency for calculations.
21.	JT	.0023 oz-in-sec^2	Moment of inertia of tachometer.
22.	KS	1.85 oz-in	Torsional restoring torque of motor shaft.
24.	B2	1. oz-in/rad/sec	Torsional damping torque.

	Symbol	Figure 2 Value CIR2 and CIR2T	Figure 3 Value CIR2B
1.	RS	1000 ohms	500 ohms
2.	RL	20000. ohms	16700 ohms
3.	R1	330000. ohms	100000 ohms
4.	R2	10000 ohms	10000. ohms
5.	R3	10000 ohms	10000 ohms
6.	R4	0	0
7.	R5	0	0
8.		Not used	Not used
9.	C1	.0068 microfarads	.015 microfarads
10.	C2	4. microfarads	4. microfarads
11.	C3	Not used	.015 microfarads